Received: 11 January 2021 | Accepted: 12 January 2021

DOI: 10.1111/obr.13213

SUPPLEMENT ARTICLE

OBESITY Reviews WILEY

Socioeconomic inequalities in overweight and obesity among 6- to 9-year-old children in 24 countries from the World Health Organization European region

Marta Buoncristiano[1] | Julianne Williams[1] | Philippa Simmonds[1] | Eha Nurk[2] | Wolfgang Ahrens[3,4] | Paola Nardone[5] | Ana Isabel Rito[6] | Harry Rutter[7] | Ingunn Holden Bergh[8] | Gregor Starc[9] | Kenisha Russell Jonsson[10] | Angela Spinelli[5] | Stefanie Vandevijvere[11] | Päivi Mäki[12] | Sanja Musić Milanović[13,14] | Benoît Salanave[15,16] | Mahmut S. Yardim[17] | Tatjana Hejgaard[18] | Anna Fijałkowska[19] | Shynar Abdrakhmanova[20,21] | Zulfiya Abdurrahmonova[22] | Vesselka Duleva[23] | Victoria Farrugia Sant'Angelo[24] | Marta García-Solano[25] | Andrea Gualtieri[26] | Enrique Gutiérrez-González[25] | Constanta Huidumac-Petrescu[27] | Jolanda Hyska[28] | Cecily C. Kelleher[29] | Enisa Kujundžić[30] | Valentina Peterkova[31] | Ausra Petrauskiene[32] | Iveta Pudule[33] | Elena Sacchini[26] | Lela Shengelia[34] | Maya Tanrygulyyeva[35] | Radka Taxová Braunerová[36] | Zhamilya Usupova[37] | Katharina Maruszczak[38] | Sergej M. Ostojic[39] | Igor Spiroski[40,41] | Dragana Stojisavljević[42,43] | Kremlin Wickramasinghe[1] | João Breda[1]

[1]World Health Organization (WHO) European Office for the Prevention and Control of Noncommunicable Diseases, Division of Country Health Programmes, WHO Regional Office for Europe, Moscow, Russian Federation

[2]Department of Nutrition Research, National Institute for Health Development, Tallinn, Estonia

[3]Leibniz Institute for Prevention Research and Epidemiology, BIPS, Bremen, Germany

[4]Faculty of Mathematics and Computer Science, University of Bremen, Bremen, Germany

[5]National Centre for Disease Prevention and Health Promotion, Italian National Institute of Health (Istituto Superiore di Sanità), Rome, Italy

[6]WHO/Europe Collaborating Center for Nutrition and Childhood Obesity - Food and Nutrition Department, National Institute of Health Dr. Ricardo Jorge, Lisbon, Portugal

[7]Department of Social and Policy Sciences, University of Bath, Bath, UK

[8]Department of Health and Inequality, Division of Mental and Physical Health, Norwegian Institute of Public Health, Oslo, Norway

[9]Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia

[10]Department of Living Conditions and Lifestyle, Public Health Agency of Sweden, Solna, Sweden

[11]Department of Epidemiology and Public Health, Sciensano, Brussels, Belgium

[12]Public Health and Welfare, Finnish Institute for Health and Welfare, Helsinki, Finland

[13]Croatian Institute of Public Health, Zagreb, Croatia

[14]School of Medicine, University of Zagreb, Zagreb, Croatia

[15]Departement of Non-Communicable Diseases and Traumatisms, Santé publique France, the French Public Health Agency, Saint Maurice, France

[16]Nutritional Surveillance and Epidemiology Team (ESEN), University Sorbonne Paris Nord, Bobigny, France

Abbreviations: BMI, body mass index; CI, confidence interval; COSI, Childhood Obesity Surveillance Initiative; HIC, high-income country; LIC, low-income country; LMIC, low-middle-income country; OR, odds ratio; SD, standard deviation; SES, socioeconomic status; UMIC, upper middle-income country; WHO, World Health Organization; NCDs, noncommunicable diseases.

[17]Faculty of Medicine, Hacettepe University, Ankara, Turkey

[18]Health Promotion and Inequality, Danish Health Authority, Copenhagen, Denmark

[19]Department of Cardiology, Institute of Mother and Child, Warsaw, Poland

[20]Department of Science and Professional Development, National Center of Public Health of the Ministry of Health of the Republic of Kazakhstan, Almaty, Kazakhstan

[21]Kazakhstan School of Public Health, Kazakhstan's Medical University, Almaty, Kazakhstan

[22]Republican Centre for Nutrition, Ministry of Health and Social Protection of Population, Dushanbe, Tajikistan

[23]Department Food and Nutrition, National Centre of Public Health and Analyses, Sofia, Bulgaria

[24]Primary Child Health Unit, Primary Health Care, Floriana, Malta

[25]Spanish Agency for Food Safety and Nutrition, Ministry of Consumer Affairs, Madrid, Spain

[26]Health Authority, Ministry of Health, San Marino, San Marino

[27]National Center for Health Assessment and Promotion, National Institute of Public Health, Bucharest, Romania

[28]Nutrition and Food Safety Sector, Institute of Public Health, Tirana, Albania

[29]College of Health and Agricultural Sciences, University College Dublin, Dublin, Ireland

[30]Center for Health Ecology, Institute of Public Health, Podgorica, Montenegro

[31]Institute of Paediatric Endocrinology, National Medical Research Centre for Endocrinology of the Ministry of Health of the Russian Federation, Moscow, Russian Federation

[32]Department of Preventive Medicine, Lithuanian University of Health Sciences, Kaunas, Lithuania

[33]Department of Research and Health Statistics, Centre for Disease and Prevention Control, Riga, Latvia

[34]Maternal, Child and Reproductive Health, National Center for Disease Control and Public Health of Georgia, Tbilisi, Georgia

[35]Scientific Research Institute of Maternal and Child Health, Ashgabat, Turkmenistan

[36]Obesity Management Centre, Institute of Endocrinology, Prague, Czech Republic

[37]Republican Center for Health Promotion and Mass Communication, Ministry of Health of the Kyrgyz Republic, Bishkek, Kyrgyzstan

[38]Department of Pediatrics, Paracelsus Medical University, Salzburg, Austria

[39]Biomedical Sciences Department, Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad, Serbia

[40]Institute of Public Health, Skopje, North Macedonia

[41]Faculty of Medicine, SS. Cyril and Methodius University, Skopje, North Macedonia

[42]Faculty of Medicine, University of Banja Luka, Banja Luka, Bosnia and Herzegovina

[43]Public Health Institute of Republic of Srpska, Banja Luka, Bosnia and Herzegovina

Correspondence
Marta Buoncristiano, Consultant, WHO European Office for the Prevention and Control of NCDs, 9 Leontyevsky Pereulok, Moscow 125009, Russian Federation.
Email: buoncristianom@who.int; marta.buoncristiano@gmail.com

Summary

Childhood overweight and obesity have significant short- and long-term negative impacts on children's health and well-being. These challenges are unequally distributed according to socioeconomic status (SES); however, previous studies have often lacked standardized and objectively measured data across national contexts to assess these differences. This study provides a cross-sectional picture of the association between SES and childhood overweight and obesity, based on data from 123,487 children aged 6–9 years in 24 countries in the World Health Organization (WHO) European region. Overall, associations were found between overweight/obesity and the three SES indicators used (parental education, parental employment status, and family-perceived wealth). Our results showed an inverse relationship between the prevalence of childhood overweight/obesity and parental education in high-income countries, whereas the opposite relationship was observed in most of the middle-income countries. The same applied to family-perceived wealth, although parental employment status appeared to be less associated with overweight and obesity or not associated at all. This paper highlights the need for close attention to context when designing interventions, as the association between SES and childhood

overweight and obesity varies by country economic development. Population-based interventions have an important role to play, but policies that target specific SES groups are also needed to address inequalities.

KEYWORDS
children, obesity, overweight, socioeconomic status

1 | INTRODUCTION

Childhood obesity presents a significant and complex global health challenge. Its causes are multifactorial driven by environmental factors including commercial and political actions, as well as social, biological, and genetic factors. There is increasing awareness of the role of obesogenic environments—"the sum of influences that the surroundings, opportunities or conditions of life have on promoting obesity in individuals or populations"[1]—in driving the rising prevalence of childhood obesity, as well as inequalities in exposure to these factors within and across populations.[2,3] Poverty is known to have significant impacts on child health and well-being,[4] and the resulting food insecurity can be associated with both undernutrition and overnutrition in countries at different stages of economic development.[5]

Overweight and obesity in children are important health problems due to their association with a range of serious short- and long-term complications.[6] Research shows that children with overweight and obesity are very likely to maintain their weight status in adult life,[7,8] leading to an increased risk of morbidity and premature mortality from noncommunicable diseases (NCDs) in childhood and adulthood.[9–12] In addition to these delayed consequences of excess body weight, children also suffer from immediate consequences, such as stigmatization, bullying in school, social exclusion, low self-esteem, and body image dissatisfaction.[13–15] Additionally, childhood and adolescent obesity has been repeatedly linked to depression and depressive symptoms.[16]

A pooled analysis of the *NCD risk factor collaboration* estimated that the number of children and adolescents aged 5–19 years with overweight worldwide to be approximately 75 (95% credible interval [CrI] 44–117) million among girls and 117 (95% CrI 70–178) million among boys in 2016. Meanwhile, the number of children with obesity was estimated at 50 (95% CrI 24–89) million among girls and 74 (95% CrI 39–125) million among boys.[17] In the same analysis, the authors mention that the previously observed trend of increasing childhood overweight and obesity in many high-income countries (HICs) appears to have plateaued. At the same time, numerous studies indicate that children in lower socioeconomic groups within these countries have not benefited from the stabilization of the trend, suggesting growing disparities in prevalence between socioeconomic groups.[18–21] Worldwide, most studies that have detected inequalities in childhood obesity prevalence due to socioeconomic status (SES) show an increase in inequalities after 2000.[22]

The World Health Organization (WHO) describes the social determinants of health as "The conditions in which people are born, grow, live, work and age."[23] These conditions affect health across the life-course via three related mechanisms.[24] Firstly, a lower SES is thought to expose an individual to long periods of psychosocial stress, which is known to be damaging to health through hormonal and nervous system reactions. Secondly, people with lower SES are more prone to exposure to risk factors such as tobacco use, air pollution, poor nutrition, and (in certain contexts) sedentary behaviors.[25,26] Finally, children born into families with lower SES are more likely to be exposed to factors such as poor maternal health *in utero*, as well as early-life influences such as early cessation of breastfeeding and earlier introduction of foods and drinks high in fat, salt, and/or sugar.[27,28] These associations are evidently at play in the case of childhood overweight and obesity, which research has repeatedly linked to parental body weight, parental education, family income, and sociodemographic factors.[29–34]

Globally, SES is negatively associated with childhood overweight and obesity in the majority of HICs. Hence, the lower a child's SES, the more likely they are to suffer from obesity.[22] However, in low-income countries (LICs) and low-middle-income countries (LMICs), it is still more likely to observe overweight and obesity among children in families with higher SES.[35,36] LICs and LMICs may also bear a "double burden" of increasing childhood overweight and obesity, coupled with the persistence of childhood undernutrition.[37]

From a regional perspective, data analyzed by Knai et al. from 22 European countries between 1990 and 2005 suggested that greater inequality in household income was positively associated with self-reported and measured child overweight prevalence.[38] Studies from the United States have also suggested that childhood obesity prevalence is inversely associated with income and education, although patterns might differ between children and adolescents.[39–41] However, in previous studies, SES indicators were defined in different ways including measures of parental education, parental occupation, family income, composite SES measures, and neighborhood-level SES indicators.[33,42,43] These studies often relied on self-reported anthropometric measures rather than standardized measurements.

Pooled results from the WHO European Childhood Obesity Surveillance Initiative (COSI) fourth round (2015–2017) indicated that 28.7% of boys and 26.5% of girls aged 7–9 years had overweight (including obesity) and 12.5% of boys and 9.0% of girls had obesity according to the WHO growth reference curves.[44] Data collected in COSI first round (2008–2009) in five European countries were analyzed in terms of SES, showing heterogeneity in the association between parental socioeconomic indicators and childhood overweight or obesity.[45]

This study aims to examine associations between the SES indicators parental education, parental employment status and family-perceived wealth, and objectively measured weight status among 6- to 9-year-old children from nationally representative samples from 24 countries within the WHO European Region.

2 | METHODS

In 2015–2017, the fourth round of COSI data collection took place in 36 countries belonging to the WHO European Region. Of these countries, 24 collected information on family SES via the optional COSI family form administered to parents/caregivers and were included in this analysis (namely, Albania, Bulgaria, Croatia, Czechia, Denmark, France, Georgia, Ireland, Italy, Kazakhstan, Kyrgyzstan, Lithuania, Latvia, Malta, Montenegro, Poland, Portugal, Romania, Russian Federation [only Moscow City], San Marino, Spain, Tajikistan, Turkey, and Turkmenistan). The study was carried out following a common protocol.[46] Nationally representative samples of children were drawn in all countries except for the Russian Federation, where data collection was carried out only in the city of Moscow. In Malta and San Marino, all children in the targeted age group were invited to participate in the study. The children were enrolled in the study through the school system (i.e., primary schools) in all countries except Czechia, where the enrolment setting was pediatric clinics. A detailed description of COSI study characteristics, including its implementation in 2015–2017, is provided elsewhere.[47]

2.1 | Classification of children's weight status

The classification of children's weight status was based on the 2007 WHO recommended growth reference for school-aged children and adolescents.[48,49] The WHO 2007 cut-offs were used to compute BMI-for-age *Z*-scores and to estimate prevalence of overweight/obesity. According to the WHO definitions, overweight and obesity are defined as a BMI-for-age value >+1 *Z*-score and >+2 *Z*-scores, respectively. Moreover, the estimated prevalence of overweight includes children with obesity.[48] Children with a biologically implausible (or extreme) BMI-for-age value were excluded from the analysis (values below −5 or above +5 *Z*-scores relative to the 2007 WHO growth reference median).[50]

2.2 | Family SES variables

We assessed family SES according to three variables: parental education, parental employment, and family-perceived wealth.

The COSI optional family record form included an item on the education and employment of the responding caregiver and his/her partner/spouse. Therefore, the information about parental education and employment was available only if the family form was completed by the mother or the father. In Bulgaria, Czechia, Italy, Malta, San Marino, Spain, and Turkey, data on education level and employment status specifically of the parents were gathered, regardless of which caregiver completed the questionnaire. Because information on family composition was not gathered in the fourth round of COSI, it was not possible to identify children living in a single-parent family nor to properly classify the educational attainment and the employment status of their parent. These children were thus excluded from the analysis, which focused on children living in a traditional two-parent family structure.

Three categories of parental education were then created: (1) low parental education (both parents with lower education); (2) medium parental education (one parent with lower education, one parent with higher education); (3) high parental education (both parents with higher education). We described parents as having "lower education" if they reported their educational attainment as "primary school or less," "secondary or high school," or "vocational school." We described parents as having "higher education" if they reported their educational attainment as "undergraduate or bachelor's degree" and "master's degree or higher."

We created two categories for parental employment status: (1) low parental employment (one or more parent(s) unemployed or economically inactive, i.e., not working at all and neither available nor looking for work); (2) high parental employment (both parents employed). Parents were classified as "employed," "unemployed," or "inactive" based on the following answer options from the optional family record form: "employed" comprises the answers "government employed," "nongovernment employed," and "self-employed"; "unemployed" is indicated by the answer "unemployed- able to work"; and "inactive" comprises the answers "unemployed unable to work," "student," "homemaker," and "retired."

We generated three categories to describe family-perceived wealth: (1) low family-perceived wealth (those who had trouble meeting the end of the month with their own earnings); (2) medium family-perceived wealth (those who met the end of the month with their own earnings without serious problems); (3) high family-perceived wealth (those who easily met the end of the month with their own earnings).

For the purpose of this paper, the following inclusion criteria were applied: (i) children aged between 6 and 9 years; (ii) children with available information on body weight, height, sex, and age; (iii) children with available information on education or employment status of both parents.

2.3 | Data analysis

The prevalence values of overweight and obesity were estimated at the country level. Differences across SES categories were tested using the Pearson's χ^2 test corrected using the Rao–Scott method.[51]

A multivariate multilevel logistic regression analysis was carried out to estimate the odds ratios (ORs) and their 95% confidence intervals (CIs) of having overweight (compared with having normal weight or thinness) for parental education (reference category: high parental

education), family-perceived wealth (reference category: high perceived wealth), and parental employment (reference category: high employment). The ORs were estimated adjusting for the child's sex and age, the degree of urbanization of the child's residence or school (urban versus rural), and the region/administrative division of the family's place of residence. The categorization of urbanization has been described elsewhere.[52] A model was estimated for each country included in the analysis. All models included random effects for primary schools attended by children to consider the clustered structure of the data. For Czechia's models, random effects for paediatric clinics where children were enrolled were used instead of primary schools. In the multivariate regression analysis, children with a missing value for any of the covariates were excluded. Sex-stratified models were also estimated for all countries.

The same regression analysis was carried out for obesity. More specifically, country-specific models for having obesity compared with having normal weight or thinness were estimated for all countries but Czechia, Denmark, Ireland, San Marino, and Tajikistan where the limited number of children with obesity did not allow reliable results. Sex-stratified models were estimated as well.

Both descriptive and regression analyses showed a high level of heterogeneity among countries in terms of the direction and magnitude of the association between overweight/obesity and SES variables. For this reason, we did not carry out any analysis pooling together data from different countries.

Sampling weights to adjust for the sampling design, oversampling, and nonresponse at the child level[47] were used in all analyses. For Lithuania, an unweighted analysis was carried out because sampling weights were not available. All analyses took account of the cluster sample design. All statistical analyses were performed in the statistical software package Stata version 15.1 (StataCorp LLC, College Station, TX, USA).

The results are presented in the tables by grouping countries in six macroregions according to United Nations "Standard Country or Area Codes for Statistical Use"[53]: Northern Europe, Western Europe, Eastern Europe, Southern Europe, Central Asia, and Western Asia. The World Bank classification of countries by income was also used to report and discuss results.[54] Countries were classified considering the year of the data collection in the following groups: HICs—Czechia, Croatia, Denmark, France, Ireland, Italy, Lithuania, Latvia, Malta, Poland, Portugal, San Marino, and Spain; upper middle-income countries (UMICs)—Albania, Bulgaria, Kazakhstan, Montenegro, Romania, Russian Federation, Turkmenistan, and Turkey; and LMICs—Kyrgyzstan, Georgia and Tajikistan.

3 | RESULTS

The initial sample included 152,748 children aged 6–9 years who were present on the day of the measurements and who had complete information on age, sex, and anthropometric measures. Overall, 89.5% of these children returned a filled out COSI family form, giving a total of 136,667 children. We excluded those children with missing information on all three SES indicators and ran the descriptive analysis on the remaining 123,487 children. The main reason for exclusion of children was the unavailability of information about parental education and/or employment of one of their parents. The subgroup of children without any missing values for all the variables used for the multivariate analyses included in total 116,575. More details are provided in Table 1.

In Table 2, the percentage of boys, children's age (mean and standard deviation [SD]) and percentage of children having overweight and obesity according to the WHO growth reference are reported by country. The table also shows how children were distributed by parental education level, parental employment status, and family-perceived wealth at the country level.

3.1 | Prevalence of overweight and obesity in children with low and high level of family SES

As shown in Figure 1A, in European HICs, the prevalence of overweight was higher among children whose parents had lower education status relative to children with high parental education (Figure 1A). The opposite situation emerged in most of the UMICs and LMICs, especially in Albania where children from families with high parental education had twice the prevalence of overweight than their peers with lower parental education.

Data showed a similar pattern when considering the level of family-perceived wealth, although the relationship was generally not as strong.

When comparing overweight prevalence among children with different levels of parental employment, no or very limited difference was observed in most of the countries, especially in HICs. Having both parents who were employed or self-employed was associated with higher level of overweight in Albania, Bulgaria, Georgia, Montenegro, Romania, and Turkey.

The patterns between SES and obesity were similar to those observed with SES and overweight. However, the association between parental education and obesity was stronger than the association between parental education and overweight. In seven European HICs, the obesity prevalence among children with low parental education was around twice of which was observed among children with high parental education.

3.2 | Adjusted ORs for having overweight or obesity related to family SES

3.2.1 | Parental education

The multivariate regression analysis confirmed the inverse association between parental education and childhood overweight in the European HICs (Figure 2). The strongest associations between having overweight and low parental education relative to peers with high parental education were observed in France (OR: 1.78; 95% CI:

TABLE 1 Children included in the analysis and availability of information on SES variables by country, COSI/WHO Europe Round 4 (2015–17)

	6- to 9-year-old children with available information on weight status[a]			Children included in the analysis[b]				
		Excluded from the analysis because of			Without information on			
Country	Total	No family form filled in	Missing information on all SES variables	Total	Parental education	Parental employment	Family-perceived wealth[c]	With complete information on all SES variables
Northern Europe								
DEN	2,697	1,743	79	875	9	13	0	853
IRE	2,200	1,327	70	803	4	13	n.c.	786
LTU	3,820	314	345	3,161	47	154	53	2,928
LVA	6,407	703	635	5,069	74	127	29	4,850
Eastern Europe								
BUL	3,386	0	183	3,203	32	58	51	3,077
CZH	1,689	290	64	1,335	11	40	40	1,251
POL	3,338	396	289	2,653	36	82	51	2,499
ROM	7,304	847	845	5,612	170	253	154	5,108
RUS	3,026	978	165	1,883	n.a	n.a.	0	1,883
Western Europe								
FRA	5,345	31	836	4,478	441	156	n.c.	3,881
Southern Europe								
ALB	6,422	3,898	340	2,184	45	92	38	2,020
CRO	2,724	78	131	2,515	24	61	17	2,418
ITA	44,363	891	3,374	40,098	0	n.c.	1,482	38,616
MAT	3,949	790	360	2,799	62	89	n.c.	2,648
MNE	3,423	698	123	2,602	35	95	39	2,451
POR	6,862	479	928	5,455	105	137	153	5,099
SMR	311	5	17	289	0	n.c.	8	281
SPA	10,874	443	696	9,735	348	363	347	8,771
Central Asia								
KAZ	4,821	520	709	3,592	92	190	82	3,265
KGZ	7,836	419	1,750	5,667	86	143	26	5,421
TJK	3,179	40	331	2,808	45	101	113	2,578
TKM	3,909	60	360	3,489	0	n.c.	77	3,412
Western Asia								
GEO	3,327	95	294	2,938	57	97	49	2,754
TUR	11,536	1,036	256	10,244	96	345	113	9,725
Total	152,748	16,081	13,180	123,487	1,819	2,609	2,922	116,575

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; n.a., not available; n.c., not collected; SES, socioeconomic status; WHO, World Health Organization.

Country abbreviations: ALB, Albania; BUL, Bulgaria; CRO, Croatia; CZH, Czechia; DEN, Denmark; FRA, France; GEO, Georgia; IRE, Ireland; ITA, Italy; KAZ, Kazakhstan; KGZ, Kyrgyzstan; LTU, Lithuania; LVA, Latvia; MAT, Malta; MNE, Montenegro; POL, Poland; POR, Portugal; ROM, Romania; RUS, Moscow City Russian Federation; SMR, San Marino; SPA, Spain; TJK, Tajikistan; TKM, Turkmenistan; TUR, Turkey.

[a]Children with available information on sex, age, body weight, and height and without implausible or extreme value of the BMI Z-score.

[b]Children aged between 6 and 9 years with available information on their weight status and on education or employment status of both parents.

[c]Family-perceived wealth—how the family met the end of the month with earnings at its disposal.

TABLE 2 Percentage of boys, children's age (mean and SD), percentage of children with overweight and obesity according to WHO definition, parental education level, parental employment status, and family-perceived wealth (i.e., how the family met the end of the month with earnings at its disposal) by country, COSI/WHO Europe round 4 (2015–17)

	Boys (%)	Age in years mean (SD)	Children's weight status (%)		Parental education (%)			Parental employment (%)		Family-perceived wealth (%)		
			Overweight	Obesity	Low	Medium	High	Low	High	Low	Medium	High
Northern Europe												
DEN	52.8	7.3 (0.4)	13.9	2.9	33.9	31.6	34.5	15.3	84.7	8.6	35.7	55.7
IRE	52.2	7.8 (1.2)	20.2	5.2	28.6	28.2	43.2	36.0	64.0	n.a.	n.a.	n.a.
LTU	50.4	7.8 (0.3)	26.1	10.5	36.0	30.3	33.7	22.3	77.7	20.5	46.0	33.5
LVA	48.3	8.3 (1.0)	24.9	8.1	32.5	31.7	35.8	22.4	77.6	20.3	59.9	19.8
Eastern Europe												
BUL	51.4	7.6 (0.2)	29.5	13.7	56.7	21.0	22.3	29.6	70.4	31.5	51.6	16.9
CZH	50.7	7.0 (0.2)	20.8	6.9	64.3	21.2	14.5	24.4	75.6	13.1	50.7	36.2
POL	50.0	8.4 (0.2)	30.6	12.8	33.2	26.4	40.5	25.5	74.5	15.2	59.5	25.3
ROM	49.1	8.5 (0.6)	28.0	11.2	58.3	14.7	27.1	36.6	63.4	25.4	44.6	30.1
RUS	49.7	7.4 (0.4)	25.0	9.0	n.a.	n.a.	n.a.	n.a.	n.a.	10.1	40.9	49.0
Western Europe												
FRA	49.6	8.2 (0.7)	20.7	6.2	23.3	29.7	47.0	26.8	73.2	n.a.	n.a.	n.a.
Southern Europe												
ALB	52.3	8.5 (0.6)	25.0	10.0	69.5	11.0	19.5	42.9	57.1	29.3	28.7	42.0
CRO	50.9	8.5 (0.3)	33.1	13.3	60.5	22.4	17.1	28.5	71.6	21.0	49.9	29.1
ITA	51.4	8.8 (0.3)	39.3	16.8	69.8	18.3	12.0	n.a.	n.a.	49.5	40.6	9.9
MAT	50.0	7.8 (0.3)	35.3	17.0	58.5	22.7	18.8	37.0	63.0	n.a.	n.a.	n.a.
MNE	52.7	7.4 (0.6)	33.0	12.7	62.9	22.0	15.1	42.1	57.9	26.5	47.8	25.7
POR	50.7	7.5 (0.6)	30.7	11.6	65.7	19.7	14.6	26.4	73.6	32.3	42.9	24.8
SMR	45.0	8.8 (0.3)	32.8	12.3	61.6	25.3	13.2	n.a.	n.a.	35.4	52.7	11.9
SPA	50.9	8.0 (1.1)	40.5	17.4	44.5	27.9	27.7	41.5	58.5	17.9	38.0	44.1
Central Asia												
KAZ	50.4	9.0 (0.5)	18.7	5.6	46.9	25.0	28.1	45.7	54.3	33.8	30.9	35.3
KGZ	50.5	7.9 (0.7)	9.7	2.6	61.0	20.0	19.0	67.6	32.4	44.5	20.3	35.3
TJK	51.7	7.4 (0.3)	7.7	1.5	73.2	21.3	5.5	74.0	26.0	45.2	22.7	32.2
TKM	49.8	7.7 (0.3)	11.8	3.1	83.4	12.9	3.7	n.a.	n.a.	7.6	32.1	60.4
Western Asia												
GEO	51.1	7.6 (0.4)	24.5	8.7	58.7	15.2	26.1	40.6	59.4	26.5	37.9	35.7
TUR	50.9	7.5 (0.4)	26.1	10.7	77.5	12.6	10.0	84.6	15.4	41.7	33.0	25.3

Note. For an explanation of the country abbreviations, see Table 1
Abbreviations: COSI, Childhood Obesity Surveillance Initiative; n.a., not available; SD, standard deviation; SES, socioeconomic status; WHO, World Health Organization.

1.36–2.32), Czechia (OR: 1.59; 95% CI: 1.00–2.54), Denmark (OR: 1.57; 95% CI: 0.95–2.60), Ireland (OR: 1.56; 95% CI: 1.00–2.43), and Portugal (OR: 1.53; 95% CI: 1.21–1.93). In contrast, a positive association—that is, the lower the parental education, the lower the likelihood for children having overweight—was estimated in Albania (OR: 0.46; 95% CI: 0.34–0.62), Georgia (OR: 0.77; 95% CI: 0.60–0.98), Romania (OR: 0.79; 95% CI: 0.64–0.97), and Kyrgyzstan (OR: 0.83; 95% CI: 0.63–1.10); while no association emerged in the other Central Asian countries.

3.2.2 | Family-perceived wealth

In most of the countries studied, the association between having overweight and family-perceived wealth tended to be in the same direction as that with parents' education, though it was slightly smaller in magnitude for some countries. Nevertheless, there were some exceptions in Bulgaria, San Marino, and Georgia, where the direction of the relationship between SES and overweight depended upon which SES variable was used. In Kazakhstan and Turkmenistan,

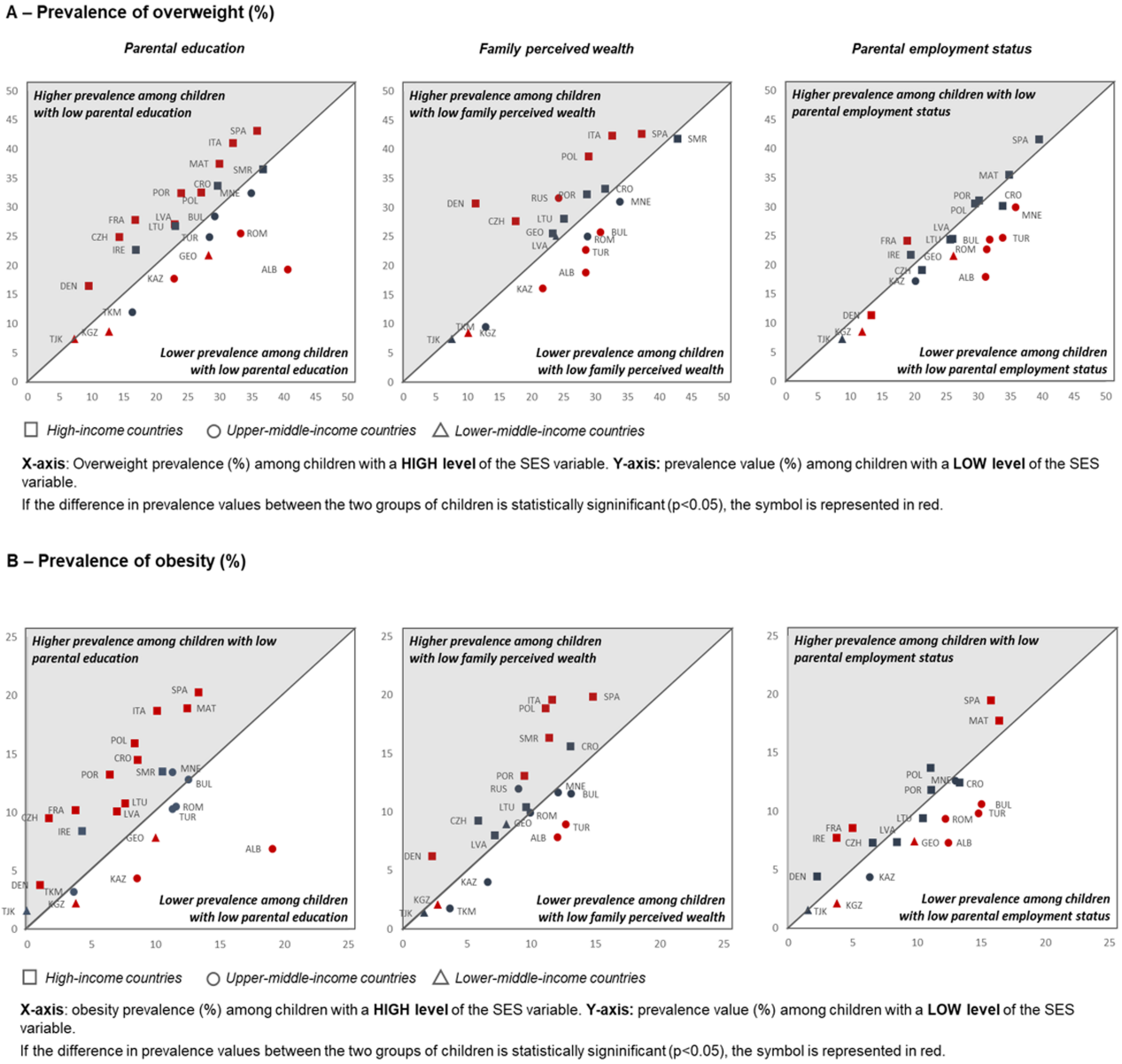

FIGURE 1 Prevalence values (%) of (A) overweightand (B) obesity among children with high and low level of the socioeconomic status (SES) indicators by country. The Childhood Obesity Surveillance Initiative (COSI)/World Health Organization (WHO) Europe Round 4 (2015–17). Overweight was defined according to the 2007 WHO recommended growth reference for school-aged children and adolescents and included obesity. For an explanation of the country abbreviations, see Table 1

children with a low level of family-perceived wealth were less likely to have overweight (OR: 0.76; 95% CI: 0.58–1.01 and OR: 0.66; 95% CI: 0.43–1.03, respectively), although parental education did not influence children's risk of having overweight.

3.2.3 | Parental employment status

Multivariate regression analyses showed that, in case of association, children with low parental employment compared with high were less likely to have overweight, especially in UMICs and LMICs, such as Albania, Bulgaria, Kyrgyzstan, Georgia, Romania, and Turkey.

The country specific adjusted ORs for having obesity compared with having normal weight or thinness confirmed the associations observed for having overweight (Figure 3). In general, the association tended to be stronger for obesity, regardless of the direction, especially for parental education.

The sex-stratified multivariate regression analysis suggested only minor differences between boys and girls when comparing ORs for having overweight/obesity related to SES variables in most of the countries. Nevertheless, the data highlight relevant differences between boys and girls in some countries. For example, in France and Malta, there was a stronger association between lower parental education and having overweight among girls than among

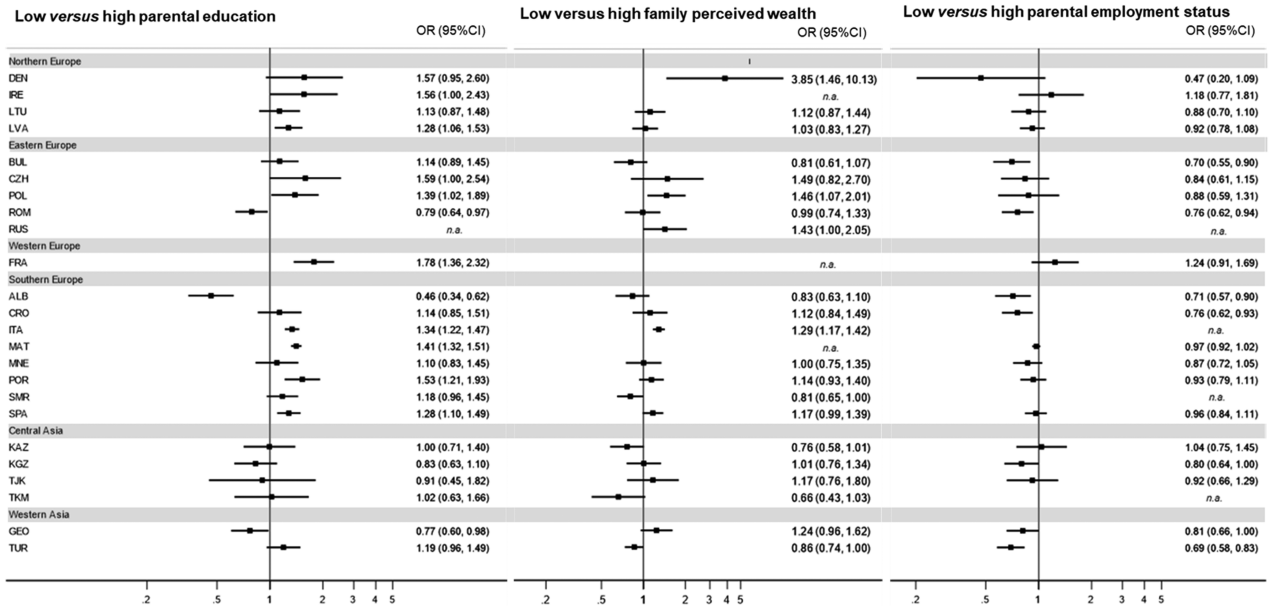

FIGURE 2 Adjusted odds ratios (ORs) of having overweight (compared with having normal weight or thinness) related to parental education, family-perceived wealth and parental employment status by country. The Childhood Obesity Surveillance Initiative (COSI)/World Health Organization (WHO) Europe Round 4 (2015–17). Overweight was defined according to the 2007 WHO recommended growth reference for school-aged children and adolescents and included obesity. Adjusted ORs and 95% confidence interval (CI) were estimated through a multilevel logistic regression analysis and adjusting for the child's sex and age, the degree of urbanization of the child's residence or school, and the region/administrative division of the family's place of residence. For an explanation of the country abbreviations, see Table 1. Abbreviation: n.a., not available

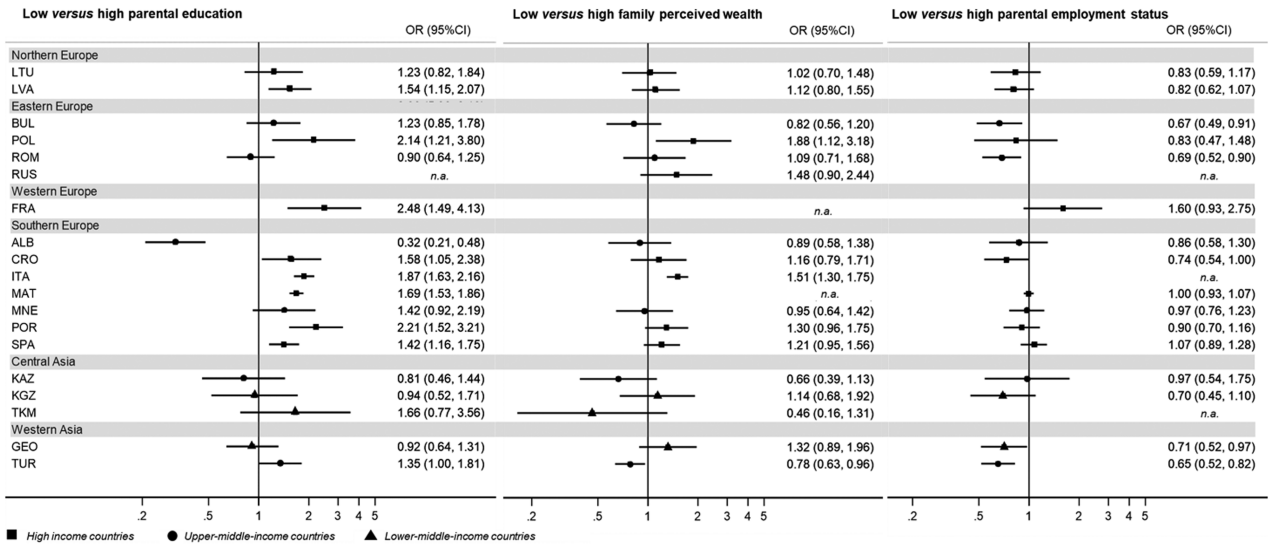

FIGURE 3 Adjusted odds ratios (ORs) of having obesity (compared with having normal weight or thinness) related to parental education, family-perceived wealth, and parental employment status by country. The Childhood Obesity Surveillance Initiative (COSI)/World Health Organization (WHO) Europe Round 4 (2015–17). Obesity was defined according to the 2007 WHO recommended growth reference for school-aged children and adolescents. Adjusted ORs and 95% confidence interval (CI) were estimated through a multilevel logistic regression analysis and adjusting for the child's sex and age, the degree of urbanization of the child's residence or school, and the region/administrative division of the family's place of residence. For an explanation of the country abbreviations, see Table 1. Abbreviation: n.a., not available

boys (see Figure S1). In Czechia, parental education tended to be more strongly associated with overweight among boys, whereas family-perceived wealth was more strongly associated with overweight among girls. Also, in Lithuania, all three of the SES variables were differently associated with overweight for boys and girls. More details about sex-stratified ORs for having overweight

and having obesity in relation to SES variables are provided in Figures S1 and S2, respectively.

4 | DISCUSSION

This study provides a cross-sectional picture of the association between SES and childhood overweight and obesity, based on data from 123,487 (116,575 in multivariate models) 6- to 9-year-old children in 24 countries in the WHO European Region. Overall, the results showed heterogeneity in the direction and magnitude of the associations between overweight/obesity and the three indicators of parental education, family-perceived wealth, and parental employment status.

Our results generally showed an inverse relationship between prevalence of childhood overweight/obesity and parental education in HICs, whereas the opposite relationship emerged in most of the UMICs and LMICs. The same was true for family-perceived wealth, while parental employment status appeared to be less associated with overweight and obesity or not associated at all.

These relationships tended to be borne out in the ORs from the multivariate regression analysis. Of note, several LMICs and UMICs showed a positive relationship between parental employment and childhood overweight/obesity. We speculate this may be due to families with two employed parents having a higher income. However, parental employment can be an unreliable indicator of SES in different contexts, as employment may be precarious and not necessarily correlated with perceived wealth.[55] Furthermore, having both parents employed may result in less time available for meal preparation, which can lead to increased reliance on processed foods that are convenient to prepare and have a stable shelf life, but may be less nutritionally balanced. A 2017 paper by Wu et al[56] examining associations between parental work characteristics and dietary patterns among children found that if only one parent was employed and worked a standard schedule, the children demonstrated greater odds of having home-prepared dinner most of the time. Mothers working long hours was associated with lower odds of eating breakfast every day, more frequent consumption of unhealthy noncore foods and a lower frequency of healthy food consumption. The authors concluded that multifaceted policy efforts should be geared toward supporting both parents, so as to create healthier family food environments, for example by giving parents greater control and choices over work times, placing limits on work hours, coordinating after-school care and community resources during parent's nonstandard work hours and providing better support to working parents.

In contrast to the findings by Wu et al, a recent paper from Europe by Fismen et al[57] examined dietary habits such as consumption of fruit, vegetables and sugar-containing soft drinks and SES and found that unhealthy food habits are associated with lower SES, particularly parental education and family-perceived wealth, but *not* parental employment status. This suggests that the relationship between parental employment and child dietary habits may be context dependent and that future work is needed: both to untangle this relationship in different countries and to understand the public health policy implications. This will help inform governments how they can best ensure that parents have the resources and structural support that is needed to ensure that all children—regardless of their SES—have access to nutritious foods.

The fact that we were only able to analyze children living in two-parent households is likely to have impacted our results. There is evidence that single parent families are at greater risk of food insecurity in HICs and that food insecurity is associated with obesity in adulthood.[58] Therefore, children in these families may be at greater risk of overweight and obesity (as a result of calorie-dense yet nutrient-poor food staples). Excluding these children may have caused us to underestimate the strength of association between SES and childhood overweight/obesity in HICs.

This study confirms what was observed by Lissner et al. in five countries that participated in COSI first round (2007–08), namely, Bulgaria, Czechia, Lithuania, Portugal, and Sweden. Heterogeneity in the association between SES indicators (i.e., parental education and employment status) and childhood overweight or obesity emerged across the five countries. Since COSI's first round of data collection, the number of countries that collected information about the family SES has been increasing every next round, up to 24 countries in the fourth round (2015–17). This effort has provided a wider picture of SES inequalities in overweight and obesity.

Our findings are also consistent with a study by Pampel et al., which found that obesity (in adulthood) rose with a nation's economic development, and the relation between SES and obesity changed.[36] In lower income countries, people with higher SES were more likely to have obesity, whereas in HICs, those with higher SES were less likely to have obesity. A recent systematic review confirmed a similar situation for childhood and adolescent overweight and obesity in HICs. The authors found an inverse relationship between SES and overweight/obesity in 72% of the included studies.[22] Meanwhile, a review by Dinsa et al. explored the relationship between SES and obesity in low- and middle-income countries. Of the 11 included studies that looked at children, all of them found a positive relationship; that is, obesity was more common among children with higher SES.[35]

In our results, the sex-stratified multivariate regression analysis suggested only minor differences between boys and girls when comparing ORs for having overweight/obesity related to SES variables in most of the countries. However, some countries did show significant differences. This demonstrates the importance of sex-disaggregated data to identify disparities; for example, a 2016 Korean study found that childhood overweight was positively related to household income in boys but inversely related to household income in girls.[59]

In 2020, evidence is beginning to emerge that lockdowns in response to the COVID-19 pandemic have had unintended consequences such as increasing less healthy behaviors (like reduced physical activity, the loss of healthy and nutritious meals in schools, and increased sedentary behaviors) among children,[60] and increased prevalence of overweight and obesity among young people.[61] It is likely that these impacts will be unequally distributed by SES and will consequently increase poverty and inequalities. Future research will be needed to expose the extent of these consequences in different contexts.

Our results identify key areas for intervention at the national level, as well as providing an opportunity for knowledge exchange between countries facing similar challenges. They add to the body of evidence linking increased risk of childhood overweight and obesity with SES and are particularly reliable given the standardized nature of data collection across countries. In general, they show a need for a blend of structural and individual approaches for effective prevention of childhood obesity. SES is multifaceted; therefore, interventions to address socioeconomic inequalities in childhood obesity should be comprehensive and address multiple risk factors.

Structural measures that reduce risk at the population level have been implemented in many countries around the world: a recent example is the proliferation of taxes on sugar-sweetened beverages. At a basic level, poverty is associated with obesity in HICs due to the lower cost of energy-dense foods[62]; therefore, fiscal interventions like taxes and subsidies can help reduce the accessibility of less healthy options while making healthier options more accessible. For example, the Mexican sugar tax was accompanied by efforts to increase the availability of fresh, potable water in schools.[63] Schools and day-care centers/kindergartens are a pragmatic site of intervention, given that they provide opportunities to deliver healthy school meals, in addition to age-congruent physical activity. There is evidence that targeted school food policies can increase consumption of specific foods such as fruits and vegetables; however, broader impacts on metabolic risk factors are limited.[64] As the onset of childhood obesity generally occurs in the early years,[65] and because we must assume that the obesogenic environment as a whole fosters obesity-related unhealthy lifestyle behaviors,[66] school interventions must be one component of more comprehensive action.

Taking a life course perspective, we know that maternal nutrition is vital to ensure optimal fetal development and reduce the risk of NCDs in later life. Improving access to quality antenatal care for all social groups can improve maternal and child health outcomes.[67] Another key area for population-level intervention is the exposure of children (especially in the early years) to digital marketing of high in fat, salt, and sugar (HFSS) foods. Given the rapid increase in access to digital devices at young ages, legislation has been slow to keep pace and protect children from subtle and manipulative marketing techniques that have been shown to increase requests for nutrient-poor and calorie-dense foods.[68,69] Meanwhile, interventions pertaining to the built environment can also significantly influence children's food environments and opportunities to practice physical activity. For example, providing safe walking and cycling routes around schools and recreation sites, in addition to reducing car dependency in urban areas, is likely to have the dual impact of increasing children's physical activity and reducing air pollution.[70] Above all, it is important to remember that broader interventions to address poverty are likely to improve child health in countries at all stages of socioeconomic development.[4]

Targeted interventions will also have a role to play in reducing disparities in childhood obesity between SES groups. Parental education and support may be of some value. For example, children who are predominantly breastfed have a reduced risk of early childhood obesity,[71,72] so effective public health interventions to promote breastfeeding in specific SES groups may help reduce inequalities, including the provision of breastfeeding facilities for working mothers, maternity leave, enforcement of the WHO Code on the Marketing of Breastmilk Substitutes, and implementation of the Baby-friendly Hospital Initiative. Later in childhood, there is evidence that children from lower SES groups have less access to structured physical activity such as sports or dancing clubs[73]; therefore, interventions to provide easier access to these activities for children from low SES neighborhoods would increase children's energy expenditure and displace a part of their sedentary time, hence lowering the risk of obesity[74,75] and reducing inequalities. From an individual treatment perspective, investment in building capacity of primary healthcare practitioners to provide timely and appropriate treatment that is free from stigma would benefit children living with overweight and obesity.[76] Any public health intervention in this area should be carefully evaluated to reduce the risk of perpetuating weight stigma and placing additional stressors on children already at risk of social exclusion.[77,78]

In the context of mounting rhetoric about the challenges posed by obesity, there are important opportunities for governments to take further action. Efforts must be made to address structural factors that create unhealthy food environments (including the role of the food and beverage industry).[79]

4.1 | Strengths and weaknesses

To the best of our knowledge, this is the largest study of its kind, using standardized methods to collect data on children's anthropometrics from nationally representative samples and using standardized indicators of SES to examine the association between SES and weight status among children. It therefore provides robust evidence to support national and regional policy decisions.

However, there are also some weaknesses that should be taken into consideration when interpreting the results. Firstly, measures of SES were self-reported and subjective, which may have introduced reporting bias, particularly in the case of family-perceived wealth. Secondly, the relevant proportion of children without information on SES indicators in some countries may have resulted in selection biases and may have affected the comparison of prevalence and OR for having overweight/obesity across these countries. Thirdly, the availability of limited information on the family structure led to the inclusion of only children living in traditional two-parent families. The exclusion of different kind of families, such as caregivers who were related to children in different ways or single-parent families, could have been a source of selection bias as well. It is possible that more vulnerable families were less likely to participate in this study, and therefore, this may have led to lower representation from these groups or even an underestimation of inequalities. Finally, in some of the countries, the results had wide CIs, reflecting a sample size not fully adequate to investigate the association between SES and overweight/obesity, especially when investigating these differences between boys and girls.

Future work on this topic would benefit from incorporating SES indicators measured at both the household and neighborhood level.

5 | CONCLUSION

This study provides a snapshot of socioeconomic inequalities in childhood overweight and obesity in 24 countries in the WHO European Region, based on three indicators of SES. The results show inequalities in childhood overweight and obesity according to parental education and family-perceived wealth, which differ according to country income status as seen in previous research. To improve children's well-being in this region, national policymakers should apply a "health in every policy" approach and be mindful of the local factors that may be worsening health inequalities at this critical stage of the life course. Ongoing surveillance is essential to monitor ongoing trends and spotlight any changes in the relationship between childhood weight status and SES as countries undergo economic and epidemiological transitions.

ACKNOWLEDGMENTS

We gratefully acknowledge all participating, children, their parents, and the schoolteachers, principals, and examiners who have participated in COSI. We also thank the teams who have collected the data in each country. We gratefully acknowledge Jelena Jakovljevic, Liza Villas and Gerben Rienk for their support in preparing and carrying out COSI round 4 data collection. We also thank Natalia Fedkina (WHO Regional Office for Europe, Moscow, Russian Federation) and Karen McColl for their support in the production of this article.

AUTHOR CONTRIBUTIONS

M.B., J.W., and P.S. conceptualized and drafted the manuscript. M.B. conducted all analyses. J.B. made substantial contribution to the conception and drafts of both the manuscript and the COSI study protocol as well as interpretation of the results. P.N., A.I.R., A.S., S.M.M., B.S., M.S.Y., T.H., K.W., and A.F. commented on the draft of the paper and contributed with data collection and data cleaning. E.N., W.A., H.R., I.H. B., G.S., K.R.J., S.V., and P.M. commented on the draft of the paper. S.A., Z.A., V.D., V.F.S., M.G.S., A.G., E.G.G., C.H.P., J.H., C.K., E.K., G.A., V.P., A.P., I.P., E.S., L.S., M.T., R.T.B., and M.T. contributed with data collection and data cleaning. All authors contributed to and approved the paper.

CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders played no role in the design of the COSI protocol, the decision to write this paper or its content.

ETHICS STATEMENT

The COSI study follows the International Ethical Guidelines for Biomedical Research Involving Human Subjects. Local ethics approval was also granted.

DISCLAIMER

J.W., J.B., and K.W. are staff members of WHO, and M.B. and P.S. are consultants with WHO. The authors alone are responsible for the views expressed in this article, and they do not necessarily represent the views, decisions, or policies of the institutions with which they are affiliated.

FUNDING INFORMATION

The authors gratefully acknowledge support through a grant from the Russian Government in the context of the WHO European Office for the Prevention and Control of NCDs. The Ministries of health of Austria, Croatia, Greece, Italy, Malta, Norway, and the Russian Federation provided financial support for the meetings at which the protocol, data collection procedures, and analyses were discussed. Data collection in the countries was made possible through funding from: *Albania*: World Health Organization (WHO) Country Office Albania and the WHO Regional Office for Europe. *Bulgaria*: WHO Regional Office for Europe. *Croatia*: Ministry of Health, Croatian Institute of Public Health and WHO Regional Office for Europe. *Czechia*: Ministry of Health of the Czech Republic, grant nr. 17-31670A and MZCR—RVO EU 00023761. *Denmark*: The Danish Ministry of Health. *France*: Santé publique France, the French Agency for Public Health. *Georgia*: WHO. *Ireland*: Health Service Executive. *Italy*: Italian Ministry of Health; Italian National Institute of Health (Istituto Superiore di Sanità). *Kazakhstan*: the Ministry of Health of the Republic of Kazakhstan within the scientific and technical program. *Kyrgyzstan*: World Health Organization. *Latvia*: Centre for Disease Prevention and Control, Ministry of Health, Latvia. *Lithuania*: Science Foundation of Lithuanian University of Health Sciences and Lithuanian Science Council and WHO. *Malta*: Ministry of Health; *Montenegro*: WHO and Institute of Public Health of Montenegro. *Poland*, National Health Program, Ministry of Health. *Portugal*: Ministry of Health Institutions, the National Institute of Health, Directorate General of Health, Regional Health Directorates and the kind technical support from the Center for Studies and Research on Social Dynamics and Health (CEIDSS). *Romania*: Ministry of Health; *Russian Federation*: WHO. *San Marino*: Health Ministry, Educational Ministry, Social Security Institute and Health Authority. *Spain*: the Spanish Agency for Food Safety & Nutrition. *Tajikistan*: WHO Country Office in Tajikistan and Ministry of Health and Social Protection. *Turkmenistan*: WHO Country Office in Turkmenistan and Ministry of Health. *Turkey*: Turkish Ministry of Health and World Bank.

ORCID

Marta Buoncristiano https://orcid.org/0000-0002-3978-8435
Philippa Simmonds https://orcid.org/0000-0003-3929-4934
Angela Spinelli https://orcid.org/0000-0002-4068-3569
Sanja Musić Milanović https://orcid.org/0000-0003-4643-1052
Radka Taxová Braunerová https://orcid.org/0000-0003-1693-4951

REFERENCES

1. Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev Med*. 1999 Dec;29(6 Pt 1):563-570. https://doi.org/10.1006/pmed.1999.0585 PMID: 10600438
2. Sahoo K, Sahoo B, Choudhury AK, Sofi NY, Kumar R, Bhadoria AS. Childhood obesity: causes and consequences. *J Family Med Prim Care*. 2015;4(2):187-192. https://doi.org/10.4103/2249-4863.154628
3. Roberto CA, Swinburn B, Hawkes C, et al. Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new

thinking. *Lancet*. 2015 Jun 13;385(9985):2400-2409. https://doi.org/10.1016/S0140-6736(14)61744-X Epub 2015 Feb 19. PMID: 25703111
4. Williams DR, Costa MV, Odunlami AO, Mohammed SA. Moving upstream: how interventions that address the social determinants of health can improve health and reduce disparities. *J Public Health Manag Pract*. 2008;14(Suppl):S8-S17. https://doi.org/10.1097/01.PHH.0000338382.36695.42
5. Tanumihardjo SA, Anderson C, Kaufer-Horwitz M, et al. Poverty, obesity, and malnutrition: an international perspective recognizing the paradox. *J Amer Diet Ass*. 2007;107(11):1966-1972.
6. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa heart study. *Pediatrics*. 1999;103(6):1175-1182.
7. Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med*. 1997;337(13):869-873.
8. Balistreri KS, Van Hook J. Trajectories of overweight among US school children: a focus on social and economic characteristics. *Matern Child Health J*. 2011;15(5):610-619.
9. Reilly JJ, Kelly J. Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *Int J Obes*. 2011;35(7):891-898Available from:. doi: https://doi.org/10.1038/ijo.2010.222
10. Dalla Valle M, Laatikainen T, Kalliokoski T. Childhood obesity in specialist care--searching for a healthy obese child. *Ann Med*. 2015;47(8):639-654.
11. Skinner AC, Perrin EM, Moss LA. Cardiometabolic risks and severity of obesity in children and young adults. *N Engl J Med*. 2015;373(14):1307-1317.
12. Andersen IG, Holm JC, Homøe P. Obstructive sleep apnea in children and adolescents with and without obesity. *Eur Arch Otorhinolaryngol*. 2019;276(3):871-878.
13. Puhl RM, Latner JD. Stigma, obesity, and the health of the nation's children. *Psychol Bull*. 2007;133(4):557-580.
14. Wardle J, Cooke L. The impact obesity on psychological well-being. *Best Pract Res Clin Endocrinol Metab*. 2005;19(3 SPEC. ISS):421-440.
15. Arias Ramos N, Calvo Sánchez MD, Fernández-Villa T, Ovalle Perandones MA, Fernández García D, Marqués-Sánchez P. Social exclusion of the adolescent with overweight: study of sociocentric social networks in the classroom. *Pediatr Obes*. 2018;13(10):614-620. https://doi.org/10.1111/ijpo.12396
16. Quek Y, Tam WWS, Zhang MWB, Ho RCM. Exploring the association between childhood and adolescent obesity and depression: a meta-analysis. *Obes Rev*. 2017;18(7):742-754.
17. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet*. 2017 Dec 16;390(10113):2627-2642. https://doi.org/10.1016/S0140-6736(17)32129-3 Epub 2017 Oct 10. PMID: 29029897; PMCID: PMC5735219
18. Stamatakis E, Wardle J, Cole TJ. Childhood obesity and overweight prevalence trends in England: evidence for growing socioeconomic disparities. *Int J Obes*. 2010;34(1):41-47Available from:. https://doi.org/10.1038/ijo.2009.217
19. Wang Y, Lim H. The global childhood obesity epidemic and the association between socio-economic status and childhood obesity. *Int Rev Psychiatry*. 2012;24(3):176-188.
20. Bammann K, Gwozdz W, Lanfer A, et al. Socioeconomic factors and childhood overweight in europe: results from the multi-centre IDEFICS study. *Pediatr Obes*. 2013;8(1):1-12.
21. Vanhelst J, Baudelet JB, Fardy PS, Béghin L, Mikulovic J, Ulmer Z. Prevalence of overweight, obesity, underweight and normal weight in French youth from 2009 to 2013. *Public Health Nutr*. 2017;20(6):959-964.
22. Chung A, Backholer K, Wong E, Palermo C, Keating C, Peeters A. Trends in child and adolescent obesity prevalence in economically advanced countries according to socioeconomic position: a systematic review. *Obes Rev*. 2016;17(3):276-295.
23. https://www.who.int/health-topics/social-determinants-of-health#tab=tab_1
24. Marmot M. Social determinants of health inequalities. *Lancet*. 2005;365(9464):1099-1104.
25. Mielke GI, Brown WJ, Nunes BP, Silva IC, Hallal PC. Socioeconomic correlates of sedentary behavior in adolescents: systematic review and meta-analysis. *Sports Med*. 2017;47(1):61-75.
26. Hajat A, Hsia C, O'Neill MS. Socioeconomic disparities and air pollution exposure: a global review. *Curr Envir Health Rpt*. 2015;2(4):440-450. https://doi.org/10.1007/s40572-015-0069-5
27. Wilkinson RG, Marmot M. (Eds). Social determinants of health: the solid facts. 2003. https://www.euro.who.int/__data/assets/pdf_file/0005/98438/e81384.pdf
28. Wang L, van Grieken A, van der Velde LA, et al. Factors associated with early introduction of complementary feeding and consumption of non-recommended foods among Dutch infants: the BeeBOFT study. *Public Health*. 2019;19:388.
29. Wang Y, Liang H, Tussing L, Braunschweig C, Caballero B, Flay B. Obesity and related risk factors among low socio-economic status minority students in Chicago. *Public Health Nutr*. 2007;10(9):927-938.
30. Ruiz M, Goldblatt P, Morrison J, et al. Impact of low maternal education on early childhood overweight and obesity in Europe. *Paediatr Perinat Epidemiol*. 2016;30(3):274-284.
31. Pereira S, Katzmarzyk PT, Gomes TN, et al. Profiling physical activity, diet, screen and sleep habits in Portuguese children. *Nutrients*. 2015;7(6):4345-4362.
32. Muthuri SK, Onywera VO, Tremblay MS, et al. Relationships between parental education and overweight with childhood overweight and physical activity in 9-11 year old children: results from a 12-country study. *PLoS ONE*. 2016;11(8):1-14.
33. Shrewsbury V, Wardle J. Socioeconomic status and adiposity in childhood: a systematic review of cross-sectional studies 1990-2005. *Obesity*. 2008;16(2):275-284.
34. Sherburne Hawkins S, Law C. A review of risk factors for overweight in preschool children: a policy perspective. *Int J Pediatr Obes*. 2006;1(4):195-209.
35. Dinsa GD, Goryakin Y, Fumagalli E, Suhrcke M. Obesity and socioeconomic status in developing countries: a systematic review. *Obes Rev*. 2012;13(11):1067-1079.
36. Pampel FC, Denney JT, Krueger PM. Obesity, SES, and economic development: a test of the reversal hypothesis. *Soc Sci Med*. 2012;74(7):1073-1081. https://doi.org/10.1016/j.socscimed.2011.12.028
37. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet*. 2020;395(10217):65-74.
38. Knai C, Lobstein T, Darmon N, Rutter H, McKee M. Socioeconomic patterning of childhood overweight status in Europe. *Int J Environ Res Public Health*. 2012;9(4):1472-1489.
39. Ogden CL, Carroll MD, Fakhouri TH, et al. Prevalence of obesity among youths by household income and education level of head of household—United States 2011–2014. *MMWR Morb Mortal Wkly Rep*. 2018;67(6):186-189. https://doi.org/10.15585/mmwr.mm6706a3
40. Wang Y, Zhang Q. Are American children and adolescents of low socioeconomic status at increased risk of obesity? Changes in the association between overweight and family income between 1971 and 2002. *Am J Clin Nutr*. 2006;84(4):707-716.

41. Singh GK, Kogan MD, Van Dyck PC, Siahpush M. Racial/ethnic, socioeconomic, and behavioral determinants of childhood and adolescent obesity in the United States: analyzing independent and joint associations. *Ann Epidemiol*. 2008;18(9):682-695.
42. Sobal J, Stunkard AJ. Socioeconomic status and obesity: a review of the literature. *Psychol Bull*. 1989;105(2):260-275.
43. McLaren L. Socioeconomic status and obesity. *Epidemiol Rev*. 2007;29(1):29-48.
44. Spinelli A, Buoncristiano M, Nardone P, et al. Thinness, overweight and obesity in 6–9-year-old children from 36 countries. The WHO European Childhood Obesity Surveillance Initiative—COSI 2015–17. *Obes Rev*. 2021:e13214.
45. Lissner L, Wijnhoven TM, Mehlig K, et al. Socioeconomic inequalities in childhood overweight: heterogeneity across five countries in the WHO European Childhood Obesity Surveillance Initiative (COSI-2008). *Int J Obes (Lond)*. 2016;40(5):796-802. https://doi.org/10.1038/ijo.2016.12
46. World Health Organization Regional Office for Europe. WHO Regional Office for Europe, "WHO European Childhood Obesity Surveillance Initiative". Protocol, 2016. *Who*; 2016:1-23.
47. Breda J, McColl K, Buoncristiano M, et al. Methodology and implementation of the WHO European Childhood Obesity Surveillance Initiative (COSI). *Obes Rev*. 2021:e13215. https://doi.org/10.1111/obr.13215
48. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ*. 2007;85(09):660-667.
49. WHO. *AnthroPlus for personal computers manual: software for assessing growth of the world's children and adolescents*. Geneva: World Health Organization; 2009:1-45. https://www.who.int/growthref/tools/who_anthroplus_manual.pdf
50. World Health Organization, 1995 Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. Geneva: WHO Technical Report Series, No. 854. http://whqlibdoc.who.int/trs/WHO_TRS_854.pdf
51. Rao JNK, Scott AJ. On chi-squared tests for multi-way tables with cell proportions estimated from survey data. *Ann Stat*. 1984;12(1):46-60.
52. Heinen MM, Bel-Serrat S, Kelleher CC, et al. Urban and rural differences in frequency of fruit, vegetable, and soft drink consumption among 6-9-year-old children from 19 countries from the WHO European region. *Obes Rev*. 2021:e13207. https://doi.org/10.1111/obr.13207
53. United Nations, United Nations Standard Country Code, Series M: Miscellaneous Statistical Papers, No. 49. New York: United Nations. ST/ESA/STAT/SER.M/49
54. Fantom N, Serajuddin U. The World Bank's Classification of Countries by Income. Policy Research Working Paper; No. 7528. World Bank, Washington, DC. © World Bank. 2016. https://openknowledge.worldbank.org/handle/10986/23628 License: CC BY 3.0 IGO
55. Kalleberg AL. Precarious work, insecure workers: employment relations in transition. *Am Sociol Rev*. 2009;74(1):1-22. https://doi.org/10.1177/000312240907400101
56. Wu JCL. Parental work characteristics and diet quality among preschool children in dual-parent households: results from a population-based cohort in Taiwan. *Public Health Nutr*. 2018;21(6):1147-1155.
57. Fismen A-S, Buoncristiano M, Williams J, et al. Socioeconomic differences in food habits among 6- to 9-year-old children from 23 countries—WHO European Childhood Obesity Surveillance Initiative (COSI 2015/2017). *Obes Rev*. 2021:e13211. https://doi.org/10.1111/obr.13211
58. Lund TB, Holm L, Tetens I, Smed S, Nielsen AL. Food insecurity in Denmark—socio-demographic determinants and associations with eating- and health-related variables. *Eur J Public Health*. 2018;28(2):283-288. https://doi.org/10.1093/eurpub/ckx121
59. Bahk J, Khang YH. Trends in childhood obesity and central adiposity between 1998-2001 and 2010-2012 according to household income and urbanity in Korea. *BMC Public Health*. 2015;16(1):18. https://doi.org/10.1186/s12889-015-2616-2
60. Pietrobelli A, Pecoraro L, Ferruzzi A, et al. Effects of COVID-19 lockdown on lifestyle behaviors in children with obesity living in Verona, Italy: a longitudinal study. *Obesity (Silver Spring)*. 2020 28(8):1382-1385. https://doi.org/10.1002/oby.22861 Epub 2020 Jul 10. PMID: 32352652; PMCID: PMC7267384
61. Yang S, Guo B, Ao L, et al. Obesity and activity patterns before and during COVID-19 lockdown among youths in China. *Clin Obes*. 2020 Dec;10(6):e12416. https://doi.org/10.1111/cob.12416 Epub 2020 Oct 2. PMID: 33009706; PMCID: PMC7646045
62. Drewnowski A, Specter SE. Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr*. January 2004;79(1):6-16. https://doi.org/10.1093/ajcn/79.1.6
63. Véliz C, Maslen H, Essman M, Taillie LS, Savulescu J. Sugar, taxes, and choice. *Hastings Cent Rep*. 2019;49(6):22-31. https://doi.org/10.1002/hast.1067
64. Micha R, Karageorgou D, Bakogianni I, et al. Effectiveness of school food environment policies on children's dietary behaviors: a systematic review and meta-analysis. *PLoS ONE*. 2018;13(3):e0194555. https://doi.org/10.1371/journal.pone.0194555
65. Cunningham SA, Kramer MR, Narayan KM. Incidence of childhood obesity in the United States. *N Engl J Med*. 2014;370(5):403-411. https://doi.org/10.1056/NEJMoa1309753
66. Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. *Lancet*. 2011 27;378(9793):804-814. https://doi.org/10.1016/S0140-6736(11)60813-1 PMID: 21872749
67. Kuhnt J, Vollmer S. Antenatal care services and its implications for vital and health outcomes of children: evidence from 193 surveys in 69 low-income and middle-income countries. *BMJ Open*. 2017;7(11):e017122. https://doi.org/10.1136/bmjopen-2017-017122
68. Tatlow-Golden M, Murrin C, Bergin R, Kerr M, O'Brien S, Livingstone B. Creating good feelings about unhealthy food: children's televised 'advertised diet' on the island of Ireland, in a climate of regulation. *Ir J Psychol*. 2015;36(1–4):83-100. https://doi.org/10.1080/03033910.2016.1194770
69. Boyland E, Tatlow-Golden M. Exposure, power and impact of food marketing on children: evidence supports strong restrictions. *Eur J Risk Regul*. 2017;8(2):224-236. https://doi.org/10.1017/err.2017.21
70. Rabl A, de Nazelle A. Benefits of shift from car to active transport. *Transport Policy*. 2012;19(1):121-131.
71. Gibbs BG, Forste R. Socioeconomic status, infant feeding practices and early childhood obesity. *Pediatr Obes*. 2014;9(2):135-146.
72. Rito AI, Buoncristiano M, Spinelli A, et al. Association between characteristics at birth, breastfeeding and obesity in 22 countries: the WHO European Childhood Obesity Surveillance Initiative—COSI 2015/2017. *Obes Facts*. 2019;12(2):226-243. https://doi.org/10.1159/000500425 Epub 2019 Apr 26. PMID: 31030194; PMCID: PMC6547266
73. Musić Milanović S, Buoncristiano M, Križan H, et al. Socioeconomic disparities in physical activity, sedentary behavior and sleep patterns among 6- to 9-year-old children from 24 countries in the WHO European region, 2021. *Obes Rev*. 2021:e13209. https://doi.org/10.1111/obr.13209
74. Brown T, Moore TH, Hooper L, et al. Interventions for preventing obesity in children. *Cochrane Database Syst Rev*. 2019;2011:7.
75. Davison KK, Lawson CT. Do attributes in the physical environment influence children's physical activity? A review of the literature. *Int J Behav Nutr Phys Act*. 2006;3(1):19.
76. Wilfley DE, Staiano AE, Altman M, et al. Improving access and systems of care for evidence-based childhood obesity treatment:

conference key findings and next steps. *Obesity*. 2017;25(1):16-29. https://doi.org/10.1002/oby.21712
77. Pont SJ, Puhl R, Cook SR, Slusser W. Section on obesity, the obesity society. Stigma experienced by children and adolescents with obesity. *Pediatrics*. 2017;140(6):e20173034. https://doi.org/10.1542/peds.2017-3034
78. Vartanian LR, Smyth JM. Primum non Nocere: obesity stigma and public health. *Bioethical Inquiry*. 2013;10(1):49-57. https://doi.org/10.1007/s11673-012-9412-9
79. Vallgårda S. Childhood obesity policies – mighty concerns, meek reactions. *Obes Rev*. 2018;19(3):295-301. https://doi.org/10.1111/obr.12639

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Buoncristiano M, Williams J, Simmonds P, et al. Socioeconomic inequalities in overweight and obesity among 6- to 9-year-old children in 24 countries from the World Health Organization European region. *Obesity Reviews*. 2021;22(S6):e13213. https://doi.org/10.1111/obr.13213