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Abbreviations: 95% confidence interval, 95% CI; odds ratio, OR; socioeconomic status, SES; WHO European Childhood Obesity Surveillance Initiative, COSI; World Health Organization, WHO.

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Summary

Physical activity, sedentary behavior, and sleep are important predictors of children's health. This paper aimed to investigate socioeconomic disparities in physical activity, sedentary behavior, and sleep across the WHO European region. This cross-sectional study used data on 124,700 children aged 6 to 9 years from 24 countries participating in the WHO European Childhood Obesity Surveillance Initiative between 2015 and 2017. Socioeconomic status (SES) was measured through parental education, parental employment status, and family perceived wealth. Overall, results showed different patterns in socioeconomic disparities in children's movement behaviors across countries. In general, high SES children were more likely to use motorized transportation. Low SES children were less likely to participate in sports clubs and more likely to have more than 2 h/day of screen time. Children with low parental education had a 2.24 [95% CI 1.94–2.58] times higher risk of practising sports for less than 2 h/week. In the pooled analysis, SES was not significantly related to active play. The relationship between SES and sleep varied by the SES indicator used. Importantly, results showed that low SES is not always associated with a higher prevalence of "less healthy" behaviors. There is a great diversity in SES patterns across countries which supports the need for country-specific, targeted public health interventions.

KEYWORDS
physical activity, sedentary behavior, sleep hygiene, social inequalities

1 | INTRODUCTION

The global burden of childhood obesity has drastically risen in the past four decades.[1] In 2016, according to recent the World Health Organization (WHO) global estimates, more than 340 million children and adolescents aged 5–19 years were living with overweight or obesity.[2]

Obesity is the consequence of a complex interplay of environmental, socioeconomic, and behavioral factors. Obesity in childhood and later in life is one of the leading risk factors for noncommunicable diseases and premature death.[3–5] Stalling the rise in obesity is of global public health concern.[6] Physical inactivity and sedentary behavior have been identified as two independent risk factors for childhood obesity.[7] There is also increasing evidence that short sleep duration results in metabolic changes that contribute to the development of obesity.[8]

Early school years are a time during which children have the opportunity to develop healthy habits that persist through adolescence into adult life. WHO recommends that children aged 5–17 years do at least an average of 60 min per day of moderate- to vigorous-intensity, mostly aerobic, physical activity across the week and that on at least 3 days a week vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone, should be incorporated.[9] It is also recommended that children have no more than 2 h a day of recreational screen time and limit sitting for extended periods.[9–11] However, according to a recent study, only 19% of children aged 11–17 years globally were sufficiently physically active in 2016.[12] Temporal trend studies suggest that since 2002 young people have become less physically active and more sedentary,[13–16] total screen time for 15-year-olds increased for more than 2 h daily on average in many countries between 2002 and 2010.[13] In order to be able to address these trends and optimize and target public health interventions, we need to have a better insight on the determinants of children's movement behaviors. Identifying socioeconomic determinants of health related behaviors is especially important because these findings can be used to inform equity policies that reduce health inequalities.

With regard to socioeconomic status (SES) and physical activity, heterogeneous results have been found thus far.[17–19] Data from the Health behavior in School-aged Children 2017/2018 study showed that physical activity participation is lower among adolescents from less affluent families.[20] While a systematic review suggested that adolescents with higher SES had higher levels of physical activity, it was also reported that 42% of the studies showed an inverse or no association.[21] Possible reasons for these observed inconsistencies were (a) the heterogeneity in the indicators of SES, (b) the mostly self-reported subjective measurement of physical activity, and (c) inconsistent criteria of measurement (frequency vs. duration) and varying domains of physical activity.[22]

Similar to physical activity, research on SES and sedentary behavior, and more specifically sedentary screen time, that is, time spent passively watching screen-based entertainment, has suggested that lower SES is associated with spending more time watching television.[23,24] Several more recent studies which included other sedentary activities (such as reading, playing computer games, and using social media) also showed that lower SES was associated with increased time watching television but not with an increase in sedentary activities overall.[25–28] Furthermore, the relationship between SES and sedentary behavior patterns may not be consistent across countries.[25]

Studies suggest that short sleep duration may also be associated with SES, with some indications that children from low socioeconomic backgrounds may be at higher risk for sleep deficiencies.[29–31]

The research on SES and physical activity, sedentary behavior, and sleep duration is complicated further by the multifaceted nature and lack of a standardized definition and metric for SES, with a number of different indicators in use. This fact, coupled with the difficulty of accurately assessing physical activity and sedentary behavior in a standardized way, has led to diversity in methods and hindered the reproducibility of results.[32] The most commonly used indicators of SES have been education, income, and occupation.[33,34] Overall, parental education seems to be the strongest predictor of physical activity in children,[33,35] but it is also known that participation in different types of physical activity varies according to family income.[36] Parental employment has been independently associated with children's physical activity and sedentary behavior as well.[37,38] Composite affluence or deprivation indices are also commonly used as measures of SES in health research, but their use is complicated in cross-country studies because of big variations in what constitutes SES in different countries.

Our aim was to investigate the socioeconomic disparities—measured as differences in indicators of parental education, perceived wealth, and employment status—in physical activity, sedentary behavior, and sleep duration among children aged 6 to 9 years in 24 countries from the WHO European Region.

2 | METHODS

In 2015–2017, the fourth round of data collection for the WHO European Childhood Obesity Surveillance Initiative (COSI) took place in 36 countries of the WHO European region.[39,40] Data were collected following a common protocol.[41] The COSI study follows the International Ethical Guidelines for Biomedical Research Involving Human Subjects,[42] and protocols for all national studies included in this paper were approved by local ethical committees, with the exception of Spain, where no local ethical committee was asked for approval since it is not mandatory.

Besides measuring children's bodyweight and height, COSI gathered information on indicators regarding children's movement behaviors (physical activity, screen time, and sleep duration), parental socioeconomic characteristics, and comorbid conditions associated with obesity. These data were collected in 24 out of the 36 countries participating in the fourth round of COSI using a common form which was filled in by children's parents or caregivers.[43] Only the countries that had information on children's physical activity, sedentary behavior, sleep, and SES were included in this analysis: Albania, Bulgaria, Croatia, Czechia, Denmark, France, Georgia, Ireland, Italy, Kazakhstan, Kyrgyzstan, Lithuania, Latvia, Malta, Montenegro, Poland, Portugal, Romania, Russian Federation (only Moscow), San Marino, Spain, Tajikistan, Turkey, and Turkmenistan.

A nationally representative sample of children was drawn in almost all of the above-mentioned countries, with exceptions in Malta and San Marino, where all classes of third graders in the country were included in the study, and in the Russian Federation where data collection was carried out only in Moscow. More information on study and sampling design are provided elsewhere.[39,44,45]

Parents were asked to report on their child's physical activity patterns, sedentary behavior, and sleep. Among these, this paper focused on the following behaviors: transportation to and from school, time spent practising sports, time spent actively/vigorously playing, time spent watching TV or using electronic devices, and hours of sleep per night. The questions and answer options used to gather information on physical activity patterns, sedentary behavior, and sleep are described in Table 1. The answer options were categorized into "healthy" and "less healthy" behaviors in order to enable the comparisons between different socioeconomic population groups. The "less healthy" behaviors included taking a motorized vehicle to and from school, participating in a sports or dancing club less than 2 h per week, playing actively or vigorously for less than 1 h a day, watching TV or using electronic devices for 2 h a day or more, and sleeping fewer than 9 h a day. The justification for the chosen cutoffs is described elsewhere.[46]

TABLE 1 Questions and their predefined answer options as included in the COSI family record form to collect data on children's physical activity, sedentary behavior, and sleep and categorization of the answer options for the paper's analyses

Family record form items—children's physical activity, screen time, and sleep duration	Answer options	"Less healthy" behavior
"How does your child usually get to and from school?	"Walking or cycling"; "Motorized vehicles"; "Combination of walking and cycling and motorized vehicles"	"Motorized vehicles"
"Is your child a member of one or more sports clubs or dancing courses (e.g., football, running, hockey, swimming, tennis, basketball, gymnastics, ballet, fitness, ballroom dancing, etc.)?"	"Yes"; "No"	<2 h/week = "None"; "1 h a week";
"Over a typical or usual week (including weekends), on how many hours does your child spend on sports and physical activities with these sport clubs or dancing courses?"	"None"; "1 h a week"; "2 h a week"; "3 h a week"; "4 h a week"; "5 h a week"; "6 h a week"; "7 h a week""; "8 h a week"; "9 h a week"; "10 h a week"; "11 h a week"	
"In his/her free time, about how many hours per day is your child usually playing actively/vigorously (e.g., running, jumping outside, or moving fitness games inside)? Please tick one box for weekdays and one box for weekend	"Never"; "less than 1 h per day"; "about 1 h per day"; "about 2 hours per day"; "about 3 or more hours per day"	<1 h/day[a]
"Outside school lessons, how much time does your child usually spend watching TV or using electronic devices such as computer, tablet, smartphone or other device (not including moving or fitness games), either at home or outside home (e.g., cafes and game centers, etc.)?" Please tick one box for weekdays and one box for weekend	Number of hours per day	≥2 h/day[b]
"At what time does your child usually go to bed on school days?" "At what time does your child usually wake up on school days?"	___ hours/__minutes	<9 h/day

Abbreviation: COSI, Childhood Obesity Surveillance Initiative.
[a]Numerical values are assigned to the items "playing actively/vigorously on a weekday" and "playing actively/vigorously on a weekend day" enabling the conversion of this item to a numerical scale ("never" = 0; "less than 1 h per day" = 0·5; "about 1 h per day" = 1; "about 2 h per day" = 2; "about 3 or more hours per day" = 3). Usual play time per day is calculated weighing weekday (5/7) and weekend hours (2/7) accordingly.
[b]Number of hours per day is calculated weighing weekday (5/7) and weekend hours (2/7) accordingly.

The family SES was measured considering the following three separate categorical variables: parental education, family perceived wealth, and parental employment status. The three SES indicators were analyzed separately and not as a composite measure of SES.

Firstly, parental education was defined in two stages. For the purpose of this study, we created binary categories to describe parents' formal educational attainment. Parents who reported their educational attainment as "primary school or less," "secondary or high school," and "vocational school" were described as having "lower education." Parents who reported their educational attainment as "undergraduate or bachelor degree" and "master degree or higher" were described as having "higher education." Then, to describe parental education from the child's perspective, we created three categories: (1) low parental education (both parents with lower education), (2) medium parental education (one parent with lower education, one parent with higher education), and (3) high parental education (both parents with higher education).

Secondly, family perceived wealth describes how easily the family met the end of a typical month with its own earnings. This was defined using three categories: (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). The first of these categories, "low family perceived wealth", was created by combining the following two answer options from the family form: "We have trouble meeting the end of the month with our earnings" and "We barely meet the end of the month with our earnings." The variables are described in more detail elsewhere.[47]

Finally, parental employment was defined in two stages. 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," "non-government 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." Thus, from the child's perspective, we defined parental employment status according to two categories: (1) low parental employment (one or more parent(s) unemployed or inactive) and (2) high parental employment (both parents employed).

The COSI family form asked about the education and employment of the responding caregiver and his/her partner/spouse, so the information about parents' education and employment was generally available only when the form was filled in by the mother or the father. In Bulgaria, Czechia, Italy, Malta, San Marino, Spain, and Turkey, however, the education and employment specifically of the parents was gathered, regardless of which caregiver filled in the form. It should be noted that the categories for parental education and employment status tend to presume a traditional two-parent family structure which does not reflect the reality for all children. The family status was not gathered in the fourth round of COSI so it was not possible to identify children living in a single-parent family and include them in the analysis.

The inclusion criteria for this paper were: (i) children aged 6 to 9 years; (ii) children with available information on at least one of the variables about physical activity, screen time, and sleep pattern; and (iii) children with available information on education or employment status of both parents.

3 | DATA ANALYSIS

For each "less healthy" behavior listed above, we calculated country-specific and pooled prevalence values, both considering all children together and stratified by each of the SES variables. We tested for differences between SES in the distribution of the responses using the Rao-Scott $\chi 2$ test, a design-adjusted version of the Pearson's $\chi 2$ test.

Country-specific multivariate multilevel logistic regression models were estimated for each behavior separately.

All models included the following covariates: family's SES variables, child's sex, age, and BMI category according to WHO growth references (normal weight, overweight (including obesity), and obesity), degree of urbanization in the child's residence or school, and the region/administrative division of the residence place. The adjusted odds ratios (ORs) and relative 95% confidence intervals (95% CIs) for parental education (reference category: both parents with high level), parental employment status (reference category: both parents employed or self-employed), and family perceived wealth (reference category: high family perceived wealth) were estimated. In some countries, one or two SES variables were not included in the analysis, as the data were not collected (see Table 2). The same regression analysis was carried out using pooled data from all countries. In this case, the model included country where children had been surveyed as a covariate. All regression models included random effects for primary schools attended by children—except for Czechia, where pediatrician clinics were used instead of schools.

Sampling weights to adjust for the sampling design, oversampling, and nonresponse (at the level of the child form) were estimated and applied for all countries that applied a sampling approach in the fourth round.[45] In the pooled analyses, a population size adjusting factor was applied to the post-stratification weights. The adjusting factor was calculated based on the number of children belonging to the targeted age group according to Eurostat figures or national official statistics for 2016. All analyses took account of the cluster sample design. A p-value of 0.05 was used to define statistical significance. All statistical analyses were performed in the statistical software package Stata version 15·1.

Only survey sites with complete information on family's SES variables were included in pooled analyses, that is, all countries except France, Ireland, Italy, Malta, Russian Federation (Moscow), San Marino, and Turkmenistan. Due to the heterogeneity in the number and type of age groups targeted by each country, the pooled analysis included only one target age group per country, namely, 7 year olds, in order to balance the contribution of each country to the pooled estimates and to limit as much as possible the differences in children's

TABLE 2 Children's sex and age, parental education, and employment status, and family perceived wealth (i.e., how the family met the end of the month with earnings at its disposal) by country and overall

	Child's characteristics		Parental education (%)			Family perceived wealth (%)			Parental employment status (%)	
	Boys, %	Age in years, mean (SD)	High	Medium	Low	High	Medium	Low	High	Low
Northern Europe										
DEN	52.2	7.2 (0.3)	34.5	31.6	33.9	57.5	35.6	6.9	84.7	15.3
IRE	52.1	7.1 (0.4)	43.3	28.3	28.5	n.a.	n.a.	n.a.	64.1	35.9
LTU	50.8	7.8 (0.3)	33.9	29.9	36.2	34.5	46.7	18.8	77.7	22.3
LVA	48.3	8.3 (1.0)	35.8	31.7	32.5	20.6	60.6	18.8	77.6	22.4
Eastern Europe										
BUL	51.5	7.6 (0.2)	22.3	21.0	56.7	17.2	52.3	30.6	70.3	29.7
CZH	51.1	7.0 (0.2)	14.5	21.2	64.3	36.4	51.1	12.5	75.6	24.4
POL	49.8	8.4 (0.2)	40.4	26.4	33.2	26.1	60.3	13.6	74.4	25.6
ROM	49.3	8.5 (0.6)	26.7	14.4	58.9	30.4	45.9	23.7	62.8	37.3
RUS	49.8	7.4 (0.4)	n.a.	n.a.	n.a.	49.2	40.9	9.9	n.a.	n.a.
Western Europe										
FRA	49.5	8.1 (0.7)	47.0	29.7	23.2	n.a.	n.a.	n.a.	73.1	26.9
Southern Europe										
ALB	52.7	8.5 (0.7)	19.5	11.0	69.5	42.2	29.2	28.7	57.1	42.9
CRO	51.3	8.5 (0.3)	17.1	22.4	60.5	29.3	50.5	20.2	71.6	28.5
ITA	51.6	8.8 (0.3)	12.0	18.3	69.8	10.0	41.0	49.0	n.a.	n.a.
MAT	50.2	7.8 (0.3)	18.7	22.6	58.7	n.a.	n.a.	n.a.	62.9	37.1
MNE	52.9	7.4 (0.6)	15.0	22.1	62.9	25.8	48.1	26.1	57.9	42.1
POR	50.8	7.5 (0.6)	14.6	19.7	65.8	26.1	44.2	29.8	73.5	26.5
SMR	45.3	8.8 (0.3)	13.2	25.3	61.6	12.5	52.7	34.9	n.a.	n.a.
SPA	50.8	8.0 (1.1)	27.7	27.9	44.5	45.7	37.8	16.5	58.5	41.5
Central Asia										
KAZ	50.5	9.0 (0.5)	28.1	25.0	47.0	36.8	30.2	33.1	54.3	45.8
KGZ	50.7	7.9 (0.7)	19.4	20.0	60.6	35.3	20.4	44.2	32.6	67.4
TJK	51.8	7.4 (0.3)	5.5	21.3	73.2	32.4	22.4	45.2	25.5	74.5
TKM	50.1	7.7 (0.3)	3.7	12.9	83.4	60.3	32.3	7.4	n.a.	n.a.
Western Asia										
GEO	51.0	7.6 (0.4)	26.1	15.2	58.7	36.5	38.2	25.3	59.5	40.5
TUR	51.0	7.5 (0.4)	10.0	12.6	77.4	25.4	33.2	41.4	15.5	84.6
Pooled estimates	51.4	7.9 (0.7)	23.5	21.6	54.9	33.9	39.8	26.3	53.3	46.7

Note: COSI/WHO Europe round 4 (2015–2017). Information on parental education was not available for Moscow. Data on family perceived wealth were not collected in France, Ireland, and Malta, while those on parental employment status were not gathered in Italy, Moscow, San Marino, and Turkmenistan. Pooled estimates were calculated including the following age groups/countries: (i) 7-year-olds from Bulgaria, Czechia, Denmark, Georgia, Kyrgyzstan, Lithuania, Latvia, Montenegro, Portugal, Spain, Tajikistan, and Turkey; (ii) 8-year-olds from Albania, Croatia, Poland, and Romania; (iii) 9-year-olds from Kazakhstan. Country abbreviations: Albania (ALB), Bulgaria (BUL), Croatia (CRO), Czechia (CZH), Denmark (DEN), France (FRA), Georgia (GEO), Ireland (IRE), Italy (ITA), Kazakhstan (KAZ), Kyrgyzstan (KGZ), Lithuania (LTU), Latvia (LVA), Malta (MAT), Montenegro (MNE), Poland (POL), Portugal (POR), Romania (ROM), Russia—only Moscow city (RUS), San Marino (SMR), Spain (SPA), Tajikistan (TJK), Turkmenistan (TKM), and Turkey (TUR). Q1, first quartile; Q3, third quartile.
Abbreviation: n.a., not available.

age. If 7-year-olds were not targeted in a country, the nearest targeted age group was chosen.

The results are presented in the tables by grouping included countries into six macro-regions according to the United Nations "Standard Country or Area Codes for Statistical Use": Northern Europe (Denmark, Ireland, Lithuania and Latvia); Western Europe (France); Eastern Europe (Bulgaria, Czechia, Poland, Romania, and Moscow); Southern Europe (Albania, Croatia, Italy, Malta, Montenegro, Portugal, San Marino, and Spain); Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan), and Western Asia (Georgia and Turkey).[48]

4 | RESULTS

In total, 124,700 children from 24 countries in the WHO European Region fourth round of COSI were included in the study (supporting information Table S1). The final number of children included in the analyses varied among countries—from below 500 in San Marino to over 40,000 in Italy. Most countries had a slightly higher proportion of boys (51.4%) than girls (Table 2). With regard to SES, more than half of the children (54.9%) came from families with low parental education. However, 73.7% of children came from families with high or medium perceived wealth, and more than half of the children (53.3%) had high parental employment status. These figures varied highly between countries, with countries from Northern and Western Europe showing lower proportions of children with low parental education. Large differences were also determined in the prevalence of investigated "less healthy" behaviors in specific countries and are described in detail in a recent paper by Whiting et al.[44]

4.1 | Prevalence of "less healthy" behaviors by SES

Analysis of the pooled data shows that traveling to and from school by motorized vehicle was most common among children from families with high parental education (45.6%), high parental employment (43.8%), and/or high family perceived wealth (41.3%) (Figure 1). A reverse socioeconomic gradient emerged in relation to practicing sports, with children from less affluent families being less engaged in these activities. On average, 70.9% of children from families with low parental education spent less than 2 h/week on sports compared to 38.2% of children with high parental education. The same gradient was recorded for parental employment and family perceived wealth. The proportion of children playing actively for less than 1 h/day, however, did not vary significantly among families with different SES. Excessive screen time was more common among children from families with lower SES, with higher proportions of children watching or using electronic devices for at least 2 h/day among families with low perceived wealth (38.4%) and low parental education (37.5%). Low sleep duration did not show any specific socioeconomic gradient, as differences among different socioeconomic groups were limited and without a clear direction (Figure 1).

Country-specific levels of behaviors by SES are given in supporting information Tables S2, S3, and S4 and show wide variations between countries.

4.2 | OR of having "less healthy" behaviors related to SES

Overall, the pooled estimates found that children of families with lower socio-economic status were less likely to travel to school via motorized vehicle (Figure 2(A)). Traveling to school via motorized vehicle was less likely among children with low parental education (OR 0.78 [95% CI 0.67–0.90]), low family perceived wealth (OR 0.68 [95% CI 0.60–0.77]), and low parental employment (OR 0.67 [95% CI 0.59–0.77]). Similar patterns, for at least one of the SES variables, emerged in all countries—although with different strength—except in Denmark and Russian Federation. In countries in Northern Europe

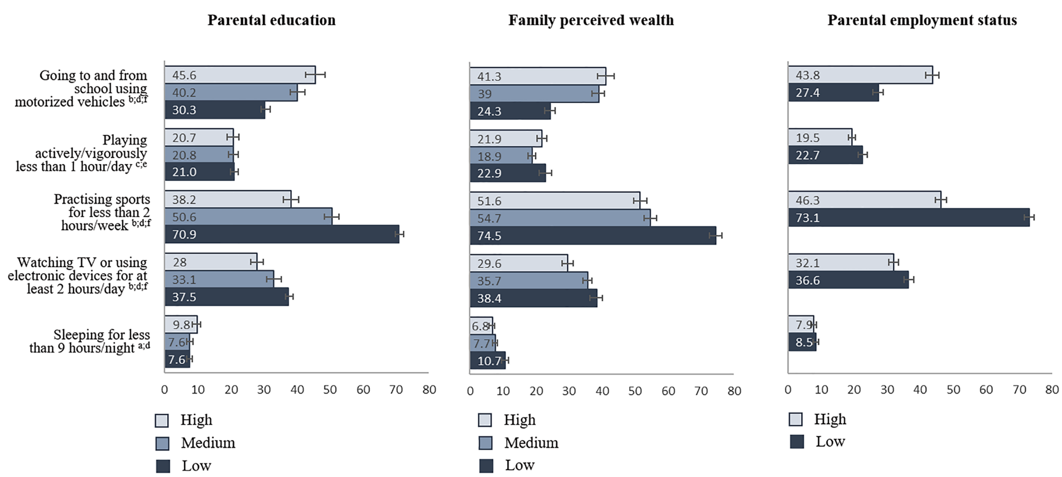

FIGURE 1 Pooled prevalence (%) of children's "less healthy" behaviors related to physical activity, screen time and sleep pattern by socioeconomic characteristics. Childhood Obesity Surveillance Initiative (COSI) round 4 (2015–2017).
Pooled estimates were calculated including the following age groups/countries: (i) 7-year-olds from Bulgaria, Czechia, Denmark, Georgia, Kyrgyzstan, Lithuania, Latvia, Montenegro, Portugal, Spain, Tajikistan, and Turkey; (ii) 8-year-olds from Albania, Croatia, Poland and Romania; iii) 9-year-olds from Kazakhstan.
[a,b] Statistically significant difference of proportions between parental educational attainments for each "less healthy" behavior—Pearson's chi-squared corrected using Rao-Scott method, $p < 0.001$ (a), $p < 0.0001$ (b). [c,d] Statistically significant difference of proportions between family perceived wealth levels for each "less healthy" behavior—Pearson's chi-squared corrected using Rao-Scott method $p < 0.001$ (c), $p < 0.0001$ (d). [e,f] Statistically significant difference of proportions between parental employment status for each "less healthy" behavior—Pearson's chi-squared corrected using Rao-Scott method, $p < 0.001$ (e), $p < 0.0001$ (f)

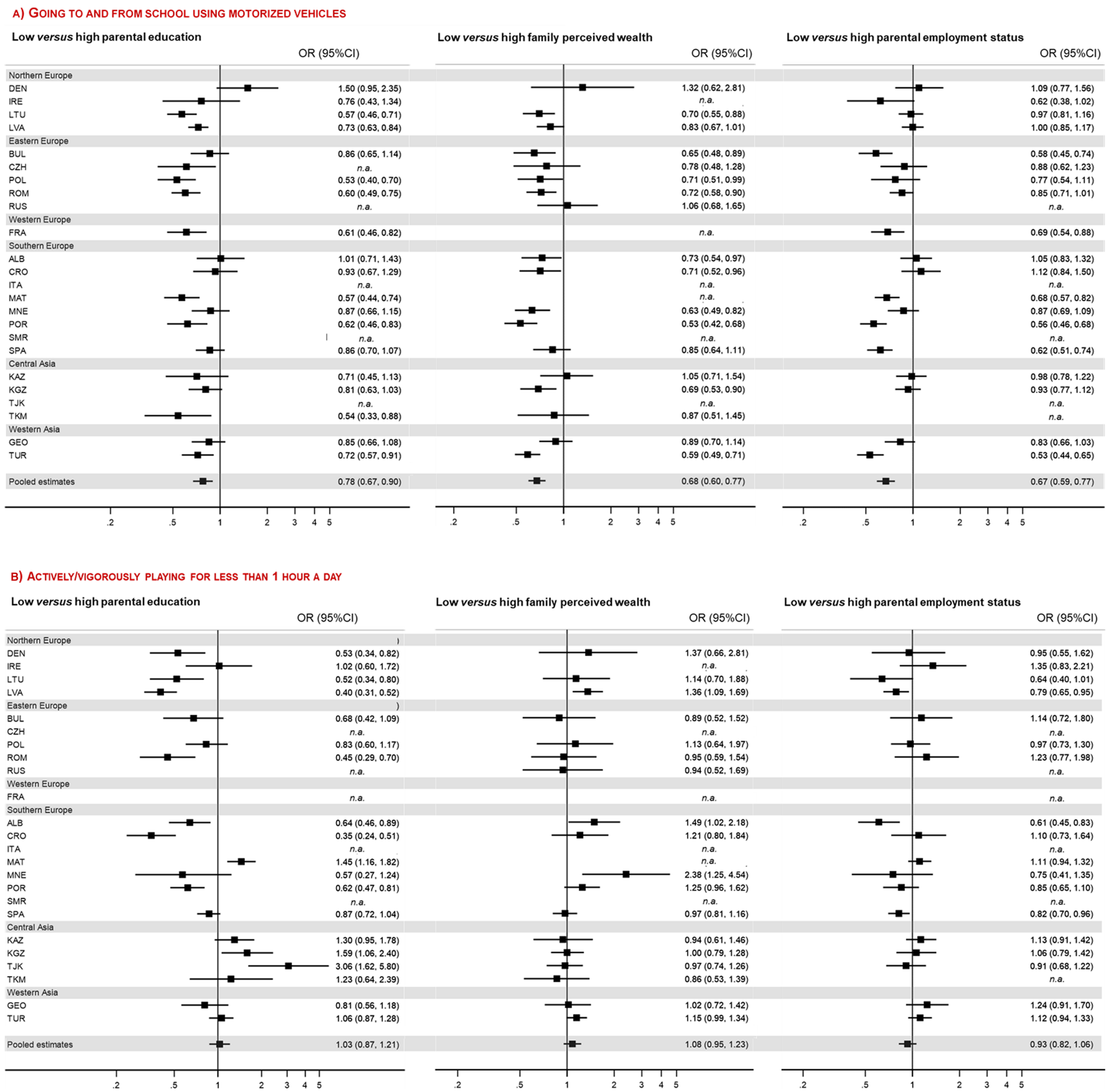

FIGURE 2 Country-specific and pooled adjusted odds ratios of having a "less healthy" physical activity behavior (compared to not having) related to parental education, family perceived wealth (i.e., how the family met the end of the month with earnings at its disposal) and parental employment status, Childhood Obesity Surveillance Initiative (COSI)/World Health Organization (WHO) Europe round 4 (2015–2017).
For an explanation of the country abbreviations, see Table 2.
Adjusted odds ratios (ORs) and 95% CI were estimated through a multilevel logistic regression analysis. Besides family characteristics (parental education, family perceived wealth, and parental employment status), all models included child's sex, age, nutritional status according to WHO definition (i.e., with normal weight-overweight-obesity), and region of residence among covariates. Pooled estimates were calculated including the following age groups/countries: (i) 7-year-olds from Bulgaria, Czechia, Denmark, Georgia, Kyrgyzstan, Lithuania, Latvia, Montenegro, Portugal, Spain, Tajikistan, and Turkey; (ii) 8-year-olds from Albania, Croatia, Poland, and Romania; (iii) 9-year-olds from Kazakhstan. Pooled regression model includes country as covariate

and Central Asia, parental employment status was not related to using motorized transportation to school.

Overall, no SES variable was associated with playing actively or vigorously for less than 1 hr a day (Figure 2(B)). However, the pooled estimates concealed different patterns in countries, especially with regards to parental education. Among most of the Northern, Eastern, and Southern European countries, children with low parental education played actively/vigorously for longer. Meanwhile, the opposite situation emerged among the Central Asian countries.

Among the three indicators of physical activity, low engagement in practicing sports showed the strongest association with family SES. In fact, lower SES was associated with higher odds of practising sports

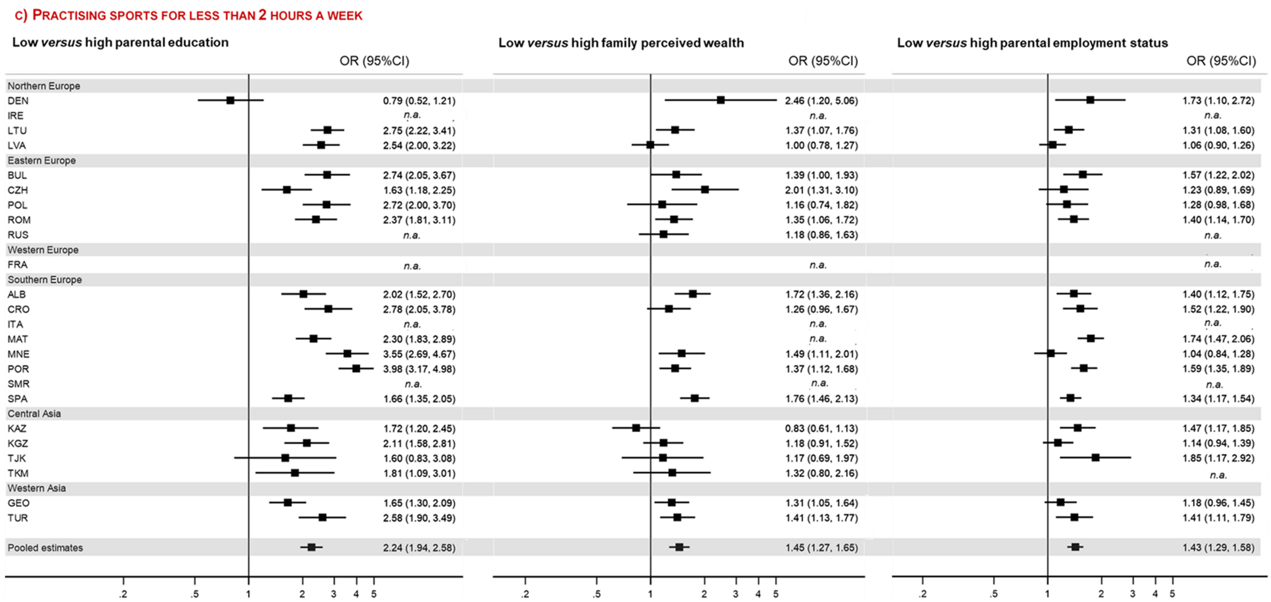

FIGURE 2 (Continued)

for less than 2 h a week in the overall pooled estimates and in almost all countries, and parental education showed a stronger association than the other two SES variables (Figure 2(C)). On average, children with medium parental education and those with low parental education were, respectively, 1.30 [95% CI 1.12–1.51] and 2.24 [95% CI 1.94–2.58] times more likely to practice sports for less than 2 h a week than children with high parental education; that is, every lower level of parental education brings a significantly higher risk for being less engaged in sports (Figure 2(C) and supporting information Table S5). Furthermore, children with low parental education (compared to high parental education) had a higher chance of low participation in sports in almost every country. ORs varied between 1.60 [95% CI 0.83–3.08] in Turkmenistan and 3.98 [95% CI 3.17–4.98] in Portugal, with the only exception being Denmark where the OR was lower than 1 (although this was not statistically significant). Similar patterns were recorded for low family perceived wealth (in comparison to high) and low parental employment (compared to high). In Central Asia, no relation between family perceived wealth and practising sports for less than 2 h a week was detected.

Lower parental education and lower perceived wealth were associated with increased screen time in pooled analyses (Figure 3). Children with low parental education were 1.33 [95% CI 1.18–1.51] times more likely to spend at least 2 h a day watching TV or using electronic devices than children with high parental education. This association was found in most Northern, Western, Eastern, and Southern European countries, although the opposite was observed in Malta, Kazakhstan, Kyrgyzstan, and Tajikistan. In pooled analyses, low family perceived wealth was associated with an increased risk for excessive screen time of 1.27 [95% CI 1.14–1.42]. Most of the European countries showed a similar pattern while there were no associations for countries in Central Asia. There were no clear patterns for parental employment status and screen time.

The relationship between SES and sleep varied by the SES indicator used. The pooled analyses showed that low family perceived wealth was associated with increased risk of shorter sleep time (less than 9 h per night), whereas low parental education was associated with a decreased risk (Figure 4). In almost all countries, children with low family perceived wealth were more likely to sleep less than 9 h/night, the pooled value for the OR being equal to 1.54 [95% CI 1.27–1.87]. Children with low parental education had lower odds of shorter sleep time compared to those with high parental education—pooled OR equal to 0.72 [95% CI 0.59–0.87]. This pattern emerged in most of the countries but not in Italy, Malta, and Spain where the association was the opposite. Finally, parental employment was not associated with sleep time: pooled OR 0.91 [95% CI 0.74–1.11], except in Northern European countries, Lithuania, and Latvia, where children with low parental employment had significantly lower odds of shorter sleep time than children with high parental employment. In Tajikistan, low parental employment was associated with a higher risk for shorter sleep time.

5 | DISCUSSION

In this study, we analyzed highly standardized data pertaining to socioeconomic disparities in physical activity, sedentary behavior, and sleep patterns of 134,874 children aged 6 to 9 years from 24 countries in the WHO European Region.

Overall, results showed heterogeneity in direction of associations across SES and with different SES indicators across countries and macro regions.

Active transportation such as walking or cycling to and from school, when it is safe to do so, presents a good opportunity to achieve daily recommended levels of physical activity, by integrating it into daily life without additional costs.[49] Our results showed that

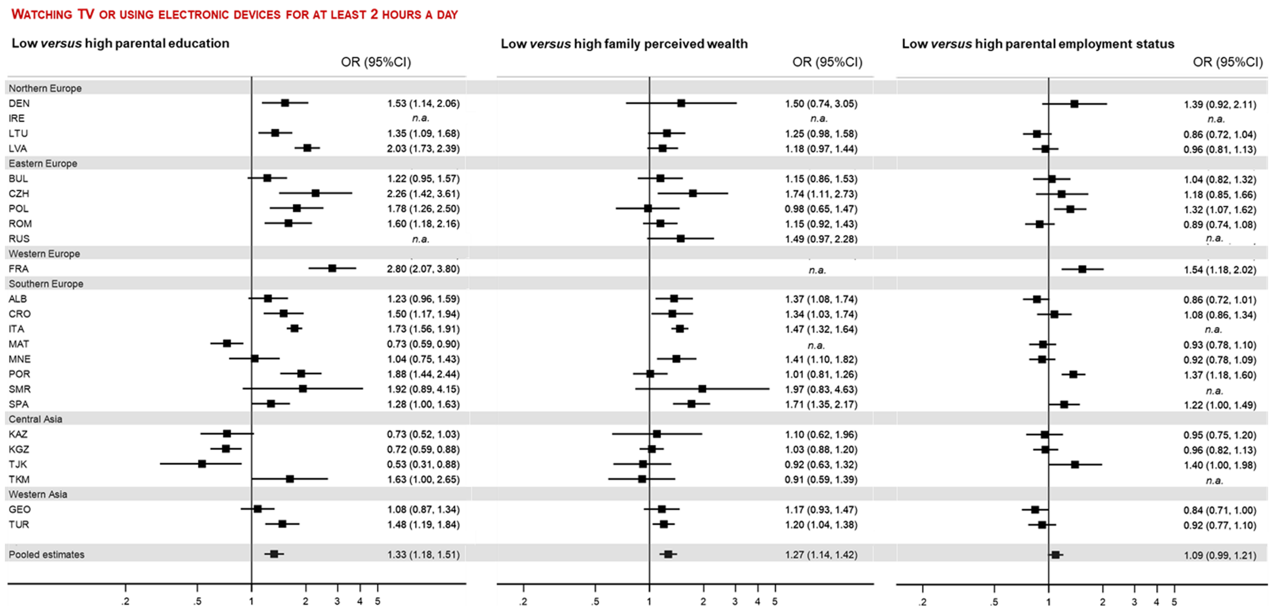

FIGURE 3 Country-specific and pooled adjusted odds ratios (ORs) of having a "less healthy" behavior on screen time (compared to not having) related to parental education, family perceived wealth (i.e., how the family met the end of the month with earnings at its disposal) and parental employment status, Childhood Obesity Surveillance Initiative (COSI)/World Health Organization (WHO) Europe round 4 (2015–2017) For an explanation of the country abbreviations, see Table 2.
[a]Adjusted ORs and 95% CI were estimated through a multilevel logistic regression analysis. Besides family characteristics (parental education, family perceived wealth and parental employment status), all models included child's sex, age, nutritional status according to WHO definition (i.e., with normal weight-overweight-obesity) and region of residence among covariates. Pooled estimates were calculated including the following age groups/countries: (i) 7-year-olds from Bulgaria, Czechia, Denmark, Georgia, Kyrgyzstan, Lithuania, Latvia, Montenegro, Portugal, Spain, Tajikistan, and Turkey; (ii) 8-year-olds from Albania, Croatia, Poland, and Romania; (iii) 9-year-olds from Kazakhstan. Pooled regression model includes country as covariate

transportation to and from school using motorized vehicles was more prevalent among children from families with a higher socioeconomic background. These findings are in line with previous research showing that active transport to and from school is related to lower SES.[50–53] Possible reasons are that lower-income households are less likely to have access to private vehicles because of associated costs[51] and parents with lower SES have less time to drive a child to and from school.[51] Interestingly, in line with other Scandinavian studies, in Denmark, active transportation was not related to parental SES.[54] This is likely due to a focus on safe and convenient cycling infrastructure in urban planning policy, in particular having safe walking and cycling lanes close to schools, as well as resulting cultural norms around cycling. No data were available on school proximity or traffic density, which could confound these findings.[55] Air pollution is also a possible factor of parental concern when choosing school transport modes, even though research has shown that health benefits of active transport outweigh the negative impact of air pollution.[56,57] These results point out the need for targeted interventions where active transportation to and from school would be promoted as a healthy choice universally, so that all parents may choose it willingly and not just out of necessity. This is especially important now in the time of the COVID-19 pandemic when many cities introduced more cycling and walking lanes due to air pollution and its role in COVID-19 spread and lethality.[58]

Active play is an activity that is natural to children and is a means through which children learn, develop emotionally, acquire motor and problem solving skills, form social relationships, and adopt habits.[59] According to the WHO Global Action Plan on Physical Activity 2018–2030, energetic active play should be encouraged within education, health, and child-care sectors due to its positive effects on growth and development.[49,60] In this study, we found that family perceived wealth and parental employment were not significantly related to active play for less than 1 h a day. In regards to parental education, there was a great diversity at the country level. In most of the European countries in the study, children of parents with lower education are at lower risk of playing for less than 1 h/day, while in Central Asian countries, it is the other way around. Previous studies on the association of SES with children's active play are scarce and conflicting.[61–63] Our findings confirm that the association between SES and active play is seemingly very context specific and that it should be investigated on a more local level. Since neighborhood characteristics are also correlated with active play, promotion of active play by creation of activity-friendly neighborhoods with formal and informal play areas and high traffic safety is important.[62]

The last "less healthy" physical activity behavior we investigated, practicing sports for less than 2 h per week, was more prevalent among children from families with lower SES and especially common in children from families with economic difficulties. The finding that children from families with lower SES had lower participation rates in organized sports aligns with previously published research from individual European countries, the European region, and other countries

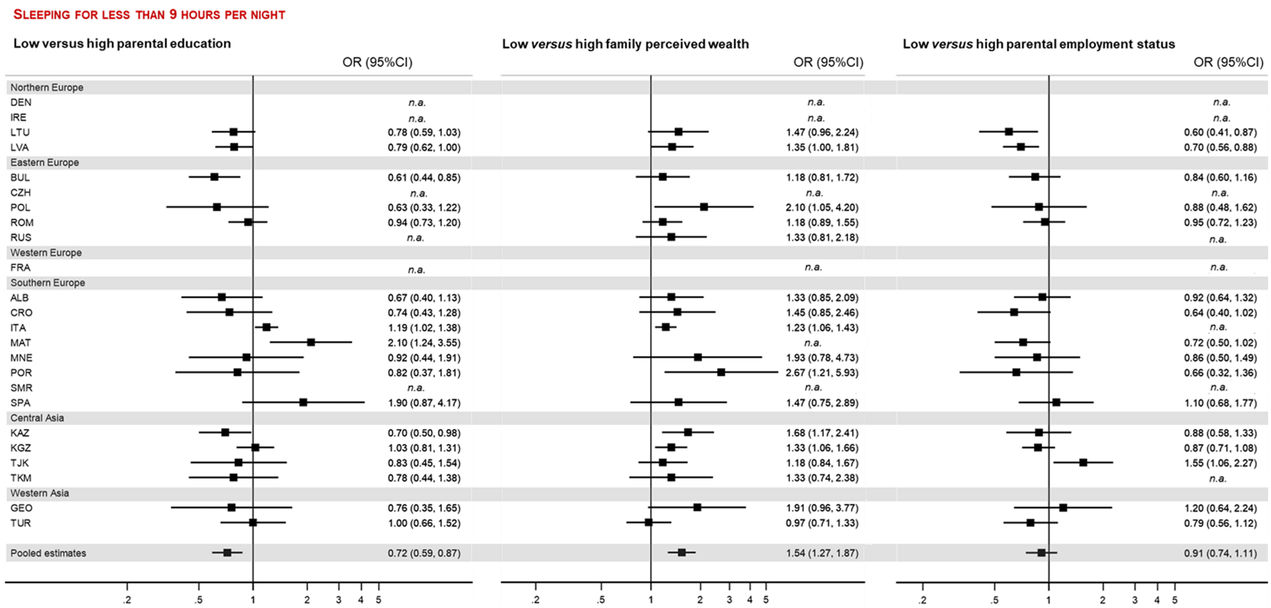

FIGURE 4 Country-specific and pooled adjusted odds ratios (ORs) of having a "less healthy" behavior on sleeping patterns (compared to not having) related to parental education, family perceived wealth (i.e., how the family met the end of the month with earnings at its disposal) and parental employment status, Childhood Obesity Surveillance Initiative (COSI)/World Health Organization (WHO) Europe round 4 (2015–2017) For an explanation of the country abbreviations, see Table 2.
[a] Adjusted ORs and 95% CI were estimated through a multilevel logistic regression analysis. Besides family characteristics (parental education, family perceived wealth and parental employment status), all models included child's sex, age, nutritional status according to WHO definition (i.e., with normal weight-overweight-obesity) and region of residence among covariates. Pooled estimates were calculated including the following age groups/countries: (i) 7-year-olds from Bulgaria, Czechia, Denmark, Georgia, Kyrgyzstan, Lithuania, Latvia, Montenegro, Portugal, Spain, Tajikistan, and Turkey; (ii) 8-year-olds from Albania, Croatia, Poland, and Romania; (iii) 9-year-olds from Kazakhstan. Pooled regression model includes country as covariate

around the world.[53,64–66] In Central Asian countries family perceived wealth was not related to practising sports for less than 2 h a week. All Central Asian countries included in our study, that is, Kazakhstan, Kyrgyzstan, Turkmenistan, and Tajikistan, show a high overall prevalence of this "less healthy" behavior in children and over half of children from these countries practice sports less than 2 h per week regardless of SES. The observed higher prevalence of participation in sports in Western and Northern Europe may be due to cultural norms regarding sports clubs, available infrastructure, or funding to support participation.

Furthermore, we found that lower parental education level was associated with a significantly higher risk of children practicing sports for less than 2 h a week, more so than the other two SES indicators (parental employment status and family perceived wealth). Compared to children with high parental education, the likelihood of lower participation in sports was increased by 30% among children with medium parental education and more than doubled among children with low parental education. These findings are in line with the results from a German study, which found that parental education was more strongly associated with children's physical activity than were employment and income.[67] Similarly, previous studies suggest that the children of parents with higher levels of education tend to participate more regularly in organized sport activities.[65] In general, families from different socioeconomic backgrounds support their children in different ways.[68] Families with higher SES usually have more financial resources to support their child's extracurricular activities and may have been taught more about the importance of regular physical activity for children's health. Therefore, high SES parents are more likely to encourage their children to actively engage in sport clubs.[69,70] Children of parents with lower SES may not be able to access as many extracurricular activities due to financial barriers and therefore are more likely to choose other available solutions for physical activity, such as free school sports and playing sports informally in public spaces such as parks.[71]

Low parental education and low family perceived wealth were found to be risk factors for watching TV or using electronic devices for at least 2 h a day, except in Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan. Similar results were found by a study from Ireland, in which children who attended schools in communities at risk of disadvantage and social exclusion spent more time watching television in comparison to children who attended other schools.[53] Even though this study used a subjective perception of family wealth, its results are consistent with studies that used material household characteristics as metrics of family affluence.[72] Other studies also confirm the relationship between sedentary behavior and lower SES, mostly using parental education as a metric,[73,74] and hypothesize that TV watching may be an affordable means of entertainment for families with limited time and financial resources.[74] Parental employment was not related to children's TV watching or electronic device using time, which suggests that increased screen time may be more influenced by a lack of funds/affordable entertainment options than a lack of time. It must be noted that this study only used screen time as an indicator of sedentary behavior, and recent research showed that screen time may not be associated with total sedentary time in children.[75]

Another factor that contributes to a healthy active lifestyle throughout the life course is sleep. We observed that the majority of children from the sample slept for 9 h per night or longer, as recommended.[11,76] The prevalence of children who slept under 9 h per night was highest among children from families with low perceived wealth. Two SES indicators, parental education and family perceived wealth, were associated with insufficient sleep in different directions: higher parental education and lower perceived wealth were risk factors for shorter sleep time among children. So far, researchers have discovered significant differences in children's sleeping patterns in groups with different SES. The relationship between lower SES and sleep disorders, later bed times, shorter sleep periods, and the lack of bedtime routine[77,78] has been explained by an interaction between environmental, biomedical, and psychosocial factors.[79] In terms of home environments, insufficient sleep in children may be explained by a lack of spatial resources, inadequate heating, and poor air conditions.[79] An association between screen media use and delayed bedtime and/or decreased total sleep time has also been observed.[80] In the biomedical realm, chronic diseases such as asthma, overweight and obesity, and others have been associated with sleep disturbances and are more prevalent in children with lower SES.[81] Lastly, in the psychosocial domain, research has found that lower income families tend to have more inconsistent daily routines, more family stressors, and less parental monitoring,[82] all of which may influence sleeping habits in children. Our finding, that higher parental education was associated with sleeping less than 9 h per night, has to our knowledge not been described in the literature and merits further investigation in future research.

5.1 | Strengths and limitations

The major strength of this study is its large population, comprising nationally representative samples from almost every country that participated. Furthermore, the standardized method of data collection and processing allowed inter-country comparisons, as well as enhanced the generalizability of our results.

There are, however, some limitations. Firstly, the presented data were self-reported. In order to obtain more reliable information, physical activity, sedentary behaviors, and sleeping patterns would need to be measured objectively. Secondly, we only looked at family level indicators of SES but it is very likely that community level SES is independently associated to investigated behaviors as well—high SES neighborhoods offer more opportunities for active transportation, outdoor play, and recreational sports. Thirdly, as some regions were more represented than the others, we need to be cautious when interpreting regional differences. Fourthly, differences in sample sizes within countries, even though they are nationally representative, may have impacted cross country comparisons. There were also varying response rates for the relevant questionnaire (the "family form") including the SES measures, and we do not know if the variation across SES measures in different countries and regions is representative of the distribution in the overall population. We did not have information available on the SES of all children with family form filled in. The information on a child's family structure was not available, and therefore, we were able to classify the parental education and employment status only when this information was available for both parents. We included for this analysis only children who had one mother and one father as primary caregivers; the exclusion of families with a different structure (or single parent families) may have resulted in selection bias and limited our capacity to accurately examine associations between SES and health behaviors. It is possible that vulnerable families were less likely to participate in this study and that this lower level of representation may have caused us to underestimate the level of inequalities. Finally, due to the use of cross-sectional data, it is not possible to make any causal inferences about the obtained results.

6 | CONCLUSION

In conclusion, our study provides a snapshot of current physical activity, sedentary behavior, and sleep patterns among children from different SES backgrounds in the WHO European region. The results show that there are significant socioeconomic disparities in physical activity, sedentary behavior, and sleep, but different "less healthy" behaviors exhibit different SES patterns and vary across countries. The results of this study also disprove the common notion that low SES is always associated with a higher prevalence of "less healthy" behaviors. As can be seen from the country level results of this study, there is much that high SES groups can learn and model from the low SES groups in specific countries. This finding should be used for empowering low SES families through public health efforts.

In general, children from families with low SES had the highest odds for low engagement in sport activities (less than 2 h per week) and for more screen time than recommended (more than 2 h per day). In contrast, children from high SES families were shown to have a higher risk of not using active transportation to and from school. Higher parental education also seemed to pose a risk for sleeping less than 9 h per night which was surprising and ought to be further investigated. Since previous research shows that both the behaviors examined in this study and SES are related to childhood obesity, a wider analysis that observed the association between SES and physical activity and eating-related behaviors in different weight status groups would be of great interest. Considering that the studied behaviors are also interrelated, future research should also look at patterns and clustering in child movement behaviors and how they are associated to SES.

Both this study and the one on socio-economic differences in eating habits published in this supplement[83] show that SES is associated with the prevalence of "less healthy" behaviors in varying patterns across countries, which is why it is necessary to develop and implement public health interventions to promote child health and prevent obesity using different strategies for different SES groups and depending on the country context. In order to continuously develop and re-evaluate such targeted interventions, it is crucial to continue nationally comparable surveillance of children's and family's activity behaviors and SES. COSI is highly relevant for this purpose, using a standardized methodology and direct measurements by trained staff to regularly provide relevant information on children's bodyweight status. It also collects school and parent reported information on lifestyle and environments, all of which facilitates comparison at the level of the WHO European region. This vital evidence can support public health professionals, policy makers, and other important stakeholders to invest in healthy active children today and thus promote healthy active adults in the future.

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CONFLICT 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.

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DISCLAIMER

JB, JW, IR, and SW are staff members of WHO, and MB is a consultant 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.

STATEMENT OF ETHICS

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

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REFERENCES

1. 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; 390(10113):2627-2642. https://doi.org/10.1016/S0140-6736(17)32129-3
2. World Health Organization. Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. Published 2020.
3. Freedman DS, Khan LK, Serdula MK, Dietz WH, Srinivasan SR, Berenson GS. The relation of childhood BMI to adult adiposity: the Bogalusa heart study. *Pediatrics*. 2005;115(1):22-27. https://doi.org/10.1542/peds.2004-0220
4. Li C, Ford ES, Zhao G, Mokdad AH. Prevalence of pre-diabetes and its association with clustering of cardiometabolic risk factors and hyperinsulinemia among U.S. adolescents: national health and nutrition examination survey 2005-2006. *Diabetes Care*. 2009;32(2): 342-347. https://doi.org/10.2337/dc08-1128
5. Dietz WH, Robinson TN. Overweight children and adolescents. *N Engl J Med*. 2005;352(20):2100-2109. https://doi.org/10.1056/NEJMcp043052
6. World Health Organization. Report of the commission on ending childhood obesity. Geneva; 2016. https://apps.who.int/iris/bitstream/handle/10665/204176/9789241510066_eng.pdf?sequence=1
7. Engeland A, Bjørge T, Tverdal A, Søgaard AJ. Obesity in adolescence and adulthood and the risk of adult mortality. *Epidemiology*. 2004;15(1):79-85. https://doi.org/10.1097/01.ede.0000100148.40711.59
8. Taheri S. The link between short sleep duration and obesity: we should recommend more sleep to prevent obesity. *Arch Dis Child*. 2006;91(11):881-884. https://doi.org/10.1136/adc.2005.093013
9. World Health Organization. WHO guidelines on physical activity and sedentary behaviour. Geneva; 2020.

10. American Academy of Pediatrics. Children, adolescents, and television. *Pediatrics*. 2001;107(2):423-426. https://doi.org/10.1542/peds.107.2.423
11. Tremblay MS, Carson V, Chaput J-P, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab*. 2016;41(6 (Suppl. 3)):S311-S327. https://doi.org/10.1139/apnm-2016-0151
12. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1·6 million participants. *Lancet Child Adolesc Heal*. 2020;4(1):23-35. https://doi.org/10.1016/S2352-4642(19)30323-2
13. Bucksch J, Sigmundova D, Hamrik Z, et al. International trends in adolescent screen-time behaviors from 2002 to 2010. *J Adolesc Health*. 2016;58(4):417-425. https://doi.org/10.1016/j.jadohealth.2015.11.014
14. Fernandes HM. Physical activity levels in Portuguese adolescents: a 10-year trend analysis (2006–2016). *J Sci Med Sport*. 2018;21(2):185-189. https://doi.org/10.1016/j.jsams.2017.05.015
15. Loprinzi PD, Davis RE. Recent temporal trends in parent-reported physical activity in children in the United States, 2009 to 2014. *Mayo Clin Proc*. 2016;91(4):477-481. https://doi.org/10.1016/j.mayocp.2016.01.006
16. Sigmund E, Sigmundová D, Badura P, Kalman M, Hamrik Z, Pavelka J. Temporal trends in overweight and obesity, physical activity and screen time among Czech adolescents from 2002 to 2014: a national health behaviour in school-aged children study. *Int J Environ Res Public Health*. 2015;12(9):11848-11868. https://doi.org/10.3390/ijerph120911848
17. Marmot M. Review of social determinants and the health divide in the WHO european region: final report. Copenhagen; 2014. https://www.euro.who.int/__data/assets/pdf_file/0004/251878/Review-of-social-determinants-and-the-health-divide-in-the-WHO-European-Region-FINAL-REPORT.pdf
18. Marmot M, Bell R. Social determinants and non-communicable diseases: time for integrated action. *BMJ*. January 2019;364:l251. https://doi.org/10.1136/bmj.l251
19. Krist L, Bürger C, Ströbele-Benschop N, et al. Association of individual and neighbourhood socioeconomic status with physical activity and screen time in seventh-grade boys and girls in Berlin, Germany: a cross-sectional study. *BMJ Open*. 2017;7(12):e017974. https://doi.org/10.1136/bmjopen-2017-017974
20. Inchley J, Currie D, Budisavljevic S, et al. (Eds). *Spotlight on Adolescent Health and Well-Being. Findings From the 2017/2018 Health Behaviour in School-Aged Children (HBSC) Survey in Europe and Canada. International Report. Volume 1. Key Findings*. Copenhagen: WHO Regional Office for Europe; 2020.
21. Stalsberg R, Pedersen AV. Effects of socioeconomic status on the physical activity in adolescents: a systematic review of the evidence. *Scand J Med Sci Sports*. 2010;20(3):368-383. https://doi.org/10.1111/j.1600-0838.2009.01047.x
22. Sherar LB, Griffin TP, Ekelund U, et al. Association between maternal education and objectively measured physical activity and sedentary time in adolescents. *J Epidemiol Community Health*. 2016;70(6):541-548. https://doi.org/10.1136/jech-2015-205763
23. Gorely T, Marshall SJ, Biddle SJH. Couch kids: correlates of television viewing among youth. *Int J Behav Med*. 2004;11(3):152-163. https://doi.org/10.1207/s15327558ijbm1103_4
24. Inchley J, Currie D (Eds). *Growing Up Unequal: Gender and Socioeconomic Differences in Young People's Health and Well-Being. Health Behaviour in School-Aged Children (HBSC) Study: International Report from the 2013/2014 Survey*. Copenhagen: World Health Organization; 2016.
25. Mielke GI, Brown WJ, Nunes BP, Silva ICM, Hallal PC. Socioeconomic correlates of sedentary behavior in adolescents: systematic review and meta-analysis. *Sport Med*. 2017;47(1):61-75. https://doi.org/10.1007/s40279-016-0555-4
26. Coombs N, Shelton N, Rowlands A, Stamatakis E. Children's and adolescents' sedentary behaviour in relation to socioeconomic position. *J Epidemiol Community Health*. 2013;67(10):868-874. https://doi.org/10.1136/jech-2013-202609
27. Van Der Horst K, Paw MJCA, Twisk JWR, Van Mechelen W. a brief review on correlates of physical activity and sedentariness in youth. *Med Sci Sport Exerc*. 2007;39(8):1241-1250. https://doi.org/10.1249/mss.0b013e318059bf35
28. Pate RR, Mitchell JA, Byun W, Dowda M. Sedentary behaviour in youth. *Br J Sports Med*. 2011;45(11):906-913. https://doi.org/10.1136/bjsports-2011-090192
29. Buzek T, Poulain T, Vogel M, et al. Relations between sleep duration with overweight and academic stress—just a matter of the socioeconomic status? *Sleep Heal*. 2019;5(2):208-215. https://doi.org/10.1016/j.sleh.2018.12.004
30. Doane LD, Breitenstein RS, Beekman C, Clifford S, Smith TJ, Lemery-Chalfant K. Early life socioeconomic disparities in children's sleep: the mediating role of the current home environment. *J Youth Adolesc*. 2019;48(1):56-70. https://doi.org/10.1007/s10964-018-0917-3
31. Breitenstein RS, Doane LD, Lemery-Chalfant K. Early life socioeconomic status moderates associations between objective sleep and weight-related indicators in middle childhood. *Sleep Heal*. 2019;5(5):470-478. https://doi.org/10.1016/j.sleh.2019.04.002
32. O'Donoghue G, Kennedy A, Puggina A, et al. Socio-economic determinants of physical activity across the life course: a "DEterminants of DIet and Physical ACtivity" (DEDIPAC) umbrella literature review. Henchoz Y, ed. *PLoS One*. 2018;13(1):e0190737. https://doi.org/10.1371/journal.pone.0190737
33. La Torre G, Masala D, De Vito E, Langiano E, Capelli G, Ricciardi W. Extra-curricular physical activity and socioeconomic status in Italian adolescents. *BMC Public Health*. 2006;6(1):22. https://doi.org/10.1186/1471-2458-6-22
34. Voorhees CC, Catellier DJ, Ashwood JS, et al. Neighborhood socioeconomic status and non school physical activity and body mass index in adolescent girls. *J Phys Act Heal*. 2009;6(6):731-740. https://doi.org/10.1123/jpah.6.6.731
35. Gorely T, Atkin AJ, Biddle SJH, Marshall SJ. Family circumstance, sedentary behaviour and physical activity in adolescents living in England: Project STIL. *Int J Behav Nutr Phys Act*. 2009;6(1):33. https://doi.org/10.1186/1479-5868-6-33
36. Kantomaa MT, Tammelin TH, Näyhä S, Taanila AM. Adolescents' physical activity in relation to family income and parents' education. *Prev Med (Baltim)*. 2007;44(5):410-415. https://doi.org/10.1016/j.ypmed.2007.01.008
37. Hawkins SS, Cole TJ, Law C. Examining the relationship between maternal employment and health behaviours in 5-year-old British children. *J Epidemiol Community Heal*. 2009;63(12):999-1004. https://doi.org/10.1136/jech.2008.084590
38. Hesketh K, Crawford D, Salmon J. Children's television viewing and objectively measured physical activity: associations with family circumstance. *Int J Behav Nutr Phys Act*. 2006;3(1):36. https://doi.org/10.1186/1479-5868-3-36
39. 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.
40. World Health Organization Regional Office for Europe. *WHO European Childhood Obesity Surveillance Initiative (COSI). Report on the fourth round of data collection 2015–2017*. Copenhagen; 2021.
41. World Health Organization Regional Office for Europe. *Childhood Obesity Surveillance Initiative (COSI) Protocol*. Copenhagen; 2016.
42. Council for International Organizations of Medical Sciences, World Health Organization. *International Ethical Guidelines for Biomedical*

Research Involving Human Subjects. Geneva, Switzerland: Council for International Organizations of Medical Sciences/World Health Organization; 2002.
43. World Health Organization. *Childhood Obesity Surveillance Initiative (COSI) – Data Collection Procedures*. Copenhagen; 2016.
44. Whiting S, Buoncristiano M, Gelius P, et al. Physical activity, screen time and sleep duration of children aged 6–9 years in 25 countries: an analysis within the WHO European Childhood Obesity Surveillance Initiative – COSI 2015/2017. *Obes Facts*. 2020;1-13.
45. Breda J, McColl K, Buoncristiano M, et al. Methodology and implementation of the WHO European Childhood Obesity Surveillance Initiative (COSI). *Obes Rev*. 2021;e13215.
46. Wijnhoven TMA, van Raaij JM, Yngve A, et al. WHO European childhood obesity surveillance initiative: health-risk behaviours on nutrition and physical activity in 6–9-year-old schoolchildren. *Public Health Nutr*. 2015;18(17):3108-3124. https://doi.org/10.1017/S1368980015001937
47. 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. *Obes Rev*. 2021;e13213. https://doi.org/10.1111/obr.13213
48. United Nations. United Nations Standard Country Code SMMSP, No. 49, ST/ESA/STAT/SER.M/49. https://unstats.un.org/unsd/methodology/m49/. Accessed December 2, 2019.
49. World Health Organization. *Global Action Plan on Physical Activity 2018-2030: More Active People for a Healthier World*. Geneva; 2018.
50. Molina-García J, Queralt A. Neighborhood built environment and socioeconomic status in relation to active commuting to school in children. *J Phys Act Heal*. 2017;14(10):761-765. https://doi.org/10.1123/jpah.2017-0033
51. Rothman L, Macpherson AK, Ross T, Buliung RN. The decline in active school transportation (AST): a systematic review of the factors related to AST and changes in school transport over time in North America. *Prev Med (Baltim)*. 2018;111(November):314-322. https://doi.org/10.1016/j.ypmed.2017.11.018
52. Su JG, Jerrett M, Mcconnell R, et al. Factors influencing whether children walk to school. *Heal Place*. 2013;22:153-161. https://doi.org/10.1016/j.physbeh.2017.03.040
53. Heinen M, Murrin C, Daly L, et al. *The Childhood Obesity Surveillance Initiative (COSI) in the Republic of Ireland: Descriptives of Childhood Obesity Risk Factors*. Dublin: Health Service Executive; 2016.
54. Chillón P, Ortega FB, Ruiz JR, et al. Active commuting to school in children and adolescents: an opportunity to increase physical activity and fitness. *Scand J Public Health*. 2010;38(8):873-879. https://doi.org/10.1177/1403494810384427
55. Larsen K, Gilliland J, Hess PM. Route-based analysis to capture the environmental influences on a child's mode of travel between home and school. *Ann Assoc Am Geogr*. 2012;102(6):1348-1365. https://doi.org/10.1080/00045608.2011.627059
56. Cepeda M, Schoufour J, Freak-Poli R, et al. Levels of ambient air pollution according to mode of transport: a systematic review. *Lancet Public Heal*. 2017;2(1):e23-e34. https://doi.org/10.1016/S2468-2667(16)30021-4
57. Mueller N, Rojas-Rueda D, Cole-Hunter T, et al. Health impact assessment of active transportation: a systematic review. *Prev Med (Baltim)*. 2015;76:103-114. https://doi.org/10.1016/j.ypmed.2015.04.010
58. Copat C, Cristaldi A, Fiore M, et al. The role of air pollution (PM and NO2) in COVID-19 spread and lethality: a systematic review. *Environ Res*. 2020;191:110129. https://doi.org/10.1016/j.envres.2020.110129
59. Ginsburg KR, Shifrin DL, Broughton DD, et al. The importance of play in promoting healthy child development and maintaining strong parent-child bonds. *Pediatrics*. 2007;119(1):182-191. https://doi.org/10.1542/peds.2006-2697
60. UK National Health Service. Physical activity guidelines for children (under 5 years); 2013.
61. Wijtzes AI, Jansen W, Bouthoorn SH, et al. Social inequalities in young children's sports participation and outdoor play. *Int J Behav Nutr Phys Act*. 2014;11(1):155. https://doi.org/10.1186/s12966-014-0155-3
62. Aarts M-J, de Vries SI, van Oers HAM, Schuit AJ. Outdoor play among children in relation to neighborhood characteristics: a cross-sectional neighborhood observation study. *Int J Behav Nutr Phys Act*. 2012;9(1):98. https://doi.org/10.1186/1479-5868-9-98
63. Nielsen G, Grønfeldt V, Toftegaard-Støckel J, Andersen LB. Predisposed to participate? The influence of family socio-economic background on children's sports participation and daily amount of physical activity. *Sport Soc*. 2012;15(1):1-27. https://doi.org/10.1080/03031853.2011.625271
64. Moraeus L, Lissner L, Yngve A, Poortvliet E, Al-Ansari U, Sjöberg A. Multi-level influences on childhood obesity in Sweden: Societal factors, parental determinants and childs lifestyle. *Int J Obes (Lond)*. 2012;36(7):969-976. https://doi.org/10.1038/ijo.2012.79
65. Post EG, Green NE, Schaefer DA, et al. Socioeconomic status of parents with children participating on youth club sport teams. *Phys Ther Sport*. 2018;32:126-132. https://doi.org/10.1016/j.ptsp.2018.05.014
66. Vella SA, Cliff DP, Okely AD. Socio-ecological predictors of participation and dropout in organised sports during childhood. *Int J Behav Nutr Phys Act*. 2014;11(1):1-10. https://doi.org/10.1186/1479-5868-11-62
67. Finger JD, Mensink GBM, Banzer W, Lampert T, Tylleskär T. Physical activity, aerobic fitness and parental socio-economic position among adolescents: the German Health Interview and Examination Survey for Children and Adolescents 2003-2006 (KiGGS). *Int J Behav Nutr Phys Act*. 2014;11(1):1-10. https://doi.org/10.1186/1479-5868-11-43
68. Arundell L, Fletcher E, Salmon J, Veitch J, Hinkley T. A systematic review of the prevalence of sedentary behavior during the after-school period among children aged 5-18 years. *Int J Behav Nutr Phys Act*. 2016;13(1):93. https://doi.org/10.1186/s12966-016-0419-1
69. Klein M, Fröhlich M, Pieter A, Emrich E. Socio-economic status and motor performance of children and adolescents. *Eur J Sport Sci*. 2016;16(2):229-236. https://doi.org/10.1080/17461391.2014.1001876
70. Ryan Dunn C, Dorsch TE, King MQ, Rothlisberger KJ. The impact of family financial investment on perceived parent pressure and child enjoyment and commitment in organized youth sport. *Fam Relat*. 2016;65(2):287-299. https://doi.org/10.1111/fare.12193
71. Brockman R, Jago R, Fox KR, Thompson JL, Cartwright K, Page AS. "Get off the sofa and go and play": family and socioeconomic influences on the physical activity of 10-11 year old children. *BMC Public Health*. 2009;9(1):3-9. https://doi.org/10.1186/1471-2458-9-253
72. Richter M, Vereecken CA, Boyce W, Maes L, Gabhainn SN, Currie CE. Parental occupation, family affluence and adolescent health behaviour in 28 countries. *Int J Public Health*. 2009;54(4):203-212. https://doi.org/10.1007/s00038-009-8018-4
73. Platat C, Perrin A-E, Oujaa M, et al. Diet and physical activity profiles in French preadolescents. *Br J Nutr*. 2006;96(3):501-507. https://doi.org/10.1079/BJN20061770
74. Leech RM, McNaughton SA, Timperio A. Clustering of children's obesity-related behaviours: associations with sociodemographic indicators. *Eur J Clin Nutr*. 2014;68(5):623-628. https://doi.org/10.1038/ejcn.2013.295
75. Hoffmann B, Kobel S, Wartha O, Kettner S, Dreyhaupt J, Steinacker JM. High sedentary time in children is not only due to screen media use: a cross-sectional study. *BMC Pediatr*. 2019;19(1):154. https://doi.org/10.1186/s12887-019-1521-8
76. Chaput JP, Dutil C, Sampasa-Kanyinga H. Sleeping hours: what is the ideal number and how does age impact this? *Nat Sci Sleep*. 2018;10:421-430. https://doi.org/10.2147/NSS.S163071

77. Ordway MR, Sadler LS, Jeon S, et al. Sleep health in young children living with socioeconomic adversity. *Res Nurs Heal*. 2020;43(4): 329-340. https://doi.org/10.1002/nur.22023
78. Biggs SN, Lushington K, James Martin A, van den Heuvel C, Kennedy JD. Gender, socioeconomic, and ethnic differences in sleep patterns in school-aged children. *Sleep Med*. 2013;14(12):1304-1309. https://doi.org/10.1016/j.sleep.2013.06.014
79. Buckhalt JA. Insufficient sleep and the socioeconomic status achievement gap. *Child Dev Perspect*. 2011;5(1):59-65. https://doi.org/10.1111/j.1750-8606.2010.00151.x
80. Hale L, Guan S. Screen time and sleep among school-aged children and adolescents: a systematic literature review. *Sleep Med Rev*. 2015; 21:50-58. https://doi.org/10.1016/j.smrv.2014.07.007
81. O'Dea JA, Dibley MJ, Rankin NM. Low sleep and low socioeconomic status predict high body mass index: a 4-year longitudinal study of Australian schoolchildren. *Pediatr Obes*. 2012;7(4):295-303. https://doi.org/10.1111/j.2047-6310.2012.00054.x
82. Evans GW, Gonnella C, Marcynyszyn LA, Gentile L, Salpekar N. The role of chaos in poverty and children's socioemotional adjustment. *Psychol Sci*. 2005;16(7):560-565. https://doi.org/10.1111/j.0956-7976.2005.01575.x
83. 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

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