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PEDIATRIC ORIGINAL ARTICLE

Multi-level influences on childhood obesity in Sweden: societal factors, parental determinants and child's lifestyle

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BACKGROUND: Swedish school children living in rural areas and in areas with low education are at excess risk of becoming overweight. This study examines influences of societal and individual characteristics (children and their parents) on prevalence of overweight and obesity, in a national sample of 7–9-year-old children.

METHOD: Anthropometric and lifestyle data were collected in a nationally representative sample of 3636 Swedish children. Overweight and obesity (International Obesity Task Force (IOTF)) data were analyzed in relation to lifestyle factors, parental weight, education and breast-feeding.

RESULTS: The prevalence of overweight was 15.6% including 2.6% obese. Urbanization level and parental characteristics (weight status and education) were related to risk of overweight. Overall less favorable lifestyle characteristics were observed in rural areas and for children of low/medium educated mothers. Boys had greater risk of obesity in semi-urban and rural areas but this was not true for girls. For children's overweight, the living area effect was attenuated in multivariate analysis, while there was an association with origin of parents, high parental weight and medium maternal education. For obesity, the living area effect remained in boys while having two non-Nordic parents predicted obesity in girls. Parental weight status was associated with obesity in both girls and boys.

CONCLUSION: Individual and societal factors influence children's weight status, and parental weight status is a strong determinant. Including overweight and obese parents in future health promoting interventions could be a strategy to prevent children from becoming overweight, but identifying those parents may prove difficult. To ensure reaching children with the greatest needs, targeting high risk areas might be a more effective approach.

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Keywords: child; overweight; lifestyle; population density; parent's weight status

INTRODUCTION

Living conditions and environmental factors can have a profound impact on people's health, even within a relatively affluent country such as Sweden. For instance, people in sparsely populated areas have a higher morbidity than those living in metropolitan areas.¹ The risk of dying from ischemic heart disease is higher in sparsely populated areas in Sweden.¹ We recently observed a similar urban–rural gradient in the prevalence of overweight and obesity among children in Sweden,² which is also observed in other developed countries.^{3–6} Furthermore, health is strongly related to socioeconomic status and studies have shown that children of parents with a lower education have the highest risk of overweight and obesity.^{7,8}

Aggregated area level information can be used as a proxy for socioeconomic status when individual data is not available.⁹ In our previous study, the urban–rural gradient in overweight and obesity was explained by the area education level,² but it is likely that it reflects environmental, cultural and individual lifestyle differences. The causes of overweight are complex and include genetic and lifestyle factors,¹⁰ as well as social and environmental circumstances.^{11,12} Parental education, physical inactivity, diet and

conditions at an early age are factors that potentially influence a child's weight.¹³ Parental weight status may have a role in the development of child overweight and obesity by means of genetics and shared environmental factors.^{14–16} To be able to promote healthy growth in different types of communities, it is important to examine how individual lifestyle varies between groups and geographic areas.

Our objective was to explore the weight status of children in a national sample with available individual data on geographic area characteristics, lifestyle, family background and parental weight status. We hypothesize that the prevalence of overweight and obesity vary by living area, as well as by parent's educational level. These associations may be explained by differences in the local physical environment but also by individual-level variation in children's and parent's lifestyle, socioeconomic and other background factors. Thus, we study the effect that physical activity, inactivity, diet and breast-feeding, as well as parent's level of education, and parental body mass index (BMI) category may have on children's weight status. We also examine how these variables vary based on level of urbanization, area education level and individual education level.

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SUBJECTS AND METHODS

Sampling

The current study was based on a nationally representative sample of school children. It followed the protocol of the World Health Organization European Childhood Obesity Surveillance Initiative (WHO COSI),¹⁷ which was jointly developed by the WHO Regional Office for Europe and the participating Member States. The procedure of inclusion, measurements and classifications of area and area education level has previously been described in more detail.² An overview of number of children in different stages of the study is described in Figure 1. Statistics Sweden selected 220 primary schools from the national school registry based on type of school and type of community, 94 agreed to participate. Letters were sent out to families of 5326 children in grade one and two, aged 7–9 years, informing parents about the study. Opt-out consent was used. After measurements, all attending pupils were given a family questionnaire that was filled out by the parents or guardians. Parents of 3636 children, 80% of measured children, completed and returned the questionnaire. Of all children available in the schools according to class lists, 32% were not included in the study, either because they were not measured (15%) or they did not return the questionnaire (17%).

Ethics

The regional Ethics Committees in both Stockholm and Gothenburg reviewed the study. Ethical approval was deemed unnecessary by the Regional Ethics Committee in Gothenburg, Sweden, while approval was granted by the Regional Ethics Committee in Stockholm.

Measurements

Measurements were performed by trained staff using standardized methods.¹⁸ Height was measured to the nearest 0.1 cm and weight to the nearest 0.1 kg. Children wore light clothing and no shoes during measurements.

Classification of living area and area education level

Location of the school was classified into urban, semi-urban or rural area based on 'degree of urbanization', a classification developed by the European Union.¹⁹ It is based on geographical contiguity, as well as population density. Area education level was classified on municipality-level into high, medium or low based on percentage of the population with more than 12 years of education.² Areas characterized by low/medium/high education level in the population are in the text called 'areas with low/medium/high education'.

Family questionnaire

The questionnaire was designed within the WHO COSI-project and was translated and slightly modified to accommodate Swedish conditions.

Figure 1. Overview of the inclusion process in the Swedish COSI study 2008. Number of children available in the schools, measured and with available family questionnaires. Distribution of participating children according to the level of urbanization, area education and parental education.

It contained questions on children's and parent's lifestyle. Parents estimated how many hours per day their child spent on (i) reading/homework, (ii) watching TV/video, (iii) engaging in computer games and (iv) playing outside. The questions were divided into weekdays and weekends and consisted of five frequencies: never, <1 h per day, about 1 h per day, about 2 h per day, about 3 h per day or more. Approximate hours per day were calculated for each variable. The three variables concerning physical inactivity (i–iii) were used to estimate total inactivity per day by adding up hours per day. A separate variable was created for screen time by combining TV and computer time. Approximate outdoor playtime per day was also calculated. Parents answered questions about whether their child was a member of a sports club, and how many days per week they participated in sports. Sports participation <3 days per week and 3 days or more was calculated.

A food frequency questionnaire containing 17 items was used. There were four frequencies of intake to choose from; every day, most days (4–6 days), some days (1–3 days), never. Consumption of sugar-sweetened and artificially sweetened beverages were both used in analyses after being dichotomized into '4 days per week or more' and '3 days per week or less'.

Parents were asked to state their highest level of completed education, which was classified into ≤9 years (low education), 10–12 years (medium education) and more than 12 years (high education). Parents reported their country of origin and children were categorized into Nordic origin if at least one parent was born in a Nordic country (Sweden Denmark, Finland, Iceland and Norway) and into non-Nordic origin if both parents were born in a non-Nordic country. Self-reported height and weight were used to calculate mother's and father's BMI and weight classes. Mother's and father's weight classes were combined into parental weight status where children were classified into having two normal weight parents, one normal weight and one pre-obese, one normal weight and one obese, two pre-obese, one pre-obese and one obese or two obese parents. Parents reported whether or not they exercised regularly (two times or more per week). In addition, breast-feeding (ever) was recorded.

The response rate for most questions regarding children's lifestyle was between 97 and 99%. Response rates for parent's lifestyle questions were lower: 86 to 98%. The varying response rates result in different numbers of children in the analyses.

Calculations and statistics

Children's BMI was calculated and classified into overweight and obesity according to International Obesity Task Force (IOTF).²⁰ BMI-, height- and weight z-scores based on the WHO Growth reference were also used.²¹ Overweight included obesity in both references and overweight, but not obese children were classified as pre-obese. Generalized linear regression models were used to test differences in lifestyle variables, anthropometric values and weight classes between girls and boys, as well as between children in different areas, individual levels of education and parental weight class. Differences were considered significant at P -level <0.05. Multiple regression analyses were used to study overweight and obesity in relation to level of urbanization, area education level, lifestyle variables, parental education and parental weight class. Variables associated with overweight or obesity at a P -value <0.1 in univariate analyses were included in the multivariate analyses where a P -value of <0.05 was considered significant. School code and internal correlation within schools were included in all models to account for the cluster design. We tested for effect modification by gender in the risk estimates by including an interaction term in the model, and performed gender-specific analysis when the interaction was significant at a P -value of <0.05. Adjusted percentages for overweight and obesity according to parental weight class was calculated by estimating the relative risk from the odds ratio (OR) multiplied by the proportion of overweight or obesity in the reference group (both parents normal weight).²² Anthropometric values are presented with means and s.d., weight classes with percentages, lifestyle variables with percentage, and risk estimates are presented as OR and 95% confidence intervals. Statistical analyses were performed with the GENLIN procedure in SPSS 18.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Anthropometry

The characteristics of children are presented in Table 1. The prevalence of overweight according to IOTF was 15.6%, including 13.0% pre-obese and 2.6% obese. The prevalence was higher

Table 1. Anthropometry and weight classification of Swedish 7–9-year-old school children, all children, girls and boys, and according to the area factors and parental education

	All children <i>n</i> = 3636 Mean (s.d.)	Girls 1760 (48.4%) Mean (s.d.)	Boys 1876 (51.6%) Mean (s.d.)	Girls–boys <i>P</i> -value ^a
Age (years)	8.4 (0.6)	8.3 (0.6)	8.4 (0.6)	0.44
Height (cm)	132.6 (6.6)	132.0 (6.7)	133.2 (6.5)	<0.0001
Height z-score ^b	0.67 (0.98)	0.61 (0.97)	0.73 (0.98)	0.0001
Weight (kg)	29.5 (5.7)	29.2 (5.8)	29.7 (5.6)	0.0009
Weight z-score ^b	0.60 (1.03)	0.53 (0.98)	0.67 (1.07)	<0.0001
BMI (kg m ^{-2b})	16.6 (2.2)	16.6 (2.3)	16.7 (2.2)	0.58
BMI z-score ^b	0.29 (1.07)	0.26 (0.99)	0.31 (1.14)	0.08
<i>Weight classification</i>				
OW (IOTF) (%)	15.6	15.8	15.4	0.77
OB (IOTF) (%)	2.6	2.8	2.5	0.40
OW (WHO) (%)	23.5	22.4	24.6	0.09
OB (WHO) (%)	6.6	5.2	7.9	<0.001
<i>Weight classification^c according to the area factors and parental education</i>				
	All children OW %	Girls/boys OW %	All children OB %	Girls/boys OB %
<i>Urbanization n = 3636</i>				
Urban	11.0	12.2/10.0	1.2	2.0/0.5
Semi-urban	14.5	12.3/17.0	3.0	2.0/4.1
Rural	18.3	18.8/17.8	3.3	3.6/3.0
<i>Area education n = 3636</i>				
High	9.8	11.4/8.4	0.6	1.0/0.2
Medium	15.8	15.8/15.8	3.0	3.2/2.8
Low	20.7	20.0/21.5	3.9	4.0/3.9
<i>Maternal education n = 3236</i>				
> 12 years	12.0	12.2/11.8	2.0	1.9/2.1
10–12 years	18.4	19.6/17.3	3.1	3.3/3.0
≤ 9 years	21.0	17.6/24.5	4.8	5.6/3.9
<i>Paternal education n = 3132</i>				
> 12 years	11.6	12.2/11.0	1.5	1.3/1.7
10–12 years	16.7	16.2/17.1	2.5	2.8/2.3
≤ 9 years	21.9	25.0/19.2	6.6	7.4/5.8

Abbreviations: BMI, body mass index; IOTF, International Obesity Task Force; OB, obesity; OW, overweight. ^a*P*-value calculated with linear regression model including schools. ^bWHO growth reference 2007. ²⁰ ^cBased on IOTF.

when using the WHO BMI z-score, overweight 23.5% ($P < 0.001$) and obesity 6.6% ($P < 0.001$). There was no difference in BMI or BMI z-score between girls and boys. The percentage of children with overweight and obesity according to living area and education levels are described in Table 1. The mean age of mothers and fathers were 41.1 (5.1) and 43.6 (5.8) years, respectively. The prevalence of overweight was 31.0% among mothers and 57.5% among fathers (Table 2).

The prevalence of overweight and obesity differed significantly between the 3636 children who had returned their family questionnaire and those who had not. Of children without questionnaires, 21.1% ($P < 0.001$) were overweight and 4.4% ($P = 0.01$) were obese according to IOTF. However, the proportion of children according to area and area education level did not differ.

Differences in lifestyle variables

Differences in parental determinants and children's lifestyle according to gender, level of urbanization, area education level and parental education are presented in Table 2 and Table 3, respectively. Differences in parental determinants and lifestyle factors between high, medium and low area education level were similar to those observed according to mother's and father's education, although slightly more pronounced differences were often observed according to mother's level of education. Children

in urban areas and children with higher parental and area education level participated in organized sports more often than rural children and children with lower parental and area education level. Boys were more often members of sports clubs and 25% of boys compared with 18% of girls participated in sports 3 days per week or more. Boys were also reported to play outdoors slightly more than girls. Children in rural areas more often played outside for 2 h or more per day than urban children, as did children of less-educated parents. Compared with urban areas, fathers living in semi-urban and rural areas exercised less while mothers exercised least in semi-urban areas. Parental exercise was more frequent in areas with high education and among parents with high education.

The majority of children were inactive > 2 h per day regardless of living area and parental and area education level. Ten percent of urban children and children with high maternal and paternal education were inactive more than 4 h per day, compared with 15% of rural children and 30% of children with low parental education. Semi-urban and rural children more often had a TV or computer in their bedroom and also spent more time on TV and computer activities than urban children. Boys were more likely to have a TV or computer in their bedroom and had more screen time than girls. More than half of the children with less-educated parents had a TV or computer in their bedroom compared with a third of children with highly educated parents.

Table 2. Parental characteristics; in total, by level of urbanization, area education and parental education

	All	Level of urbanization			Area education			Maternal education			Paternal education		
		Urban ^a	Semi-urban	Rural	High ^a	Medium	Low	> 12 years ^a	10–12 years	≤ 9 years	> 12 years ^a	10–12 years	≤ 9 years
<i>Parental determinants</i>													
Paternal education > 12 years	33.9	52.6	32.5 ^b	24.8 ^c	62.9	28.6 ^c	17.2 ^c	57.2	16.3 ^c	4.7 ^c	—	—	—
Maternal education > 12 years	45.1	60.0	43.6 ^b	37.9 ^b	68.2	41.0 ^c	32.1 ^c	—	—	—	76.2	31.0 ^c	23.3 ^c
Non-Nordic origin	8.2	8.7	11.3	7.1	4.3	9.0 ^b	10.4 ^b	5.2	8.3	32.2 ^c	7.7	6.7	16.2 ^c
Regular exercise, mother	62.6	61.1	58.0	64.7	66.9	60.7 ^b	62.7	66.6	60.6 ^b	43.6 ^c	66.9	62.1 ^b	57.4 ^b
Regular exercise, father	54.9	61.8	49.6 ^b	52.6 ^b	66.6	51.8 ^c	49.6 ^c	60.7	51.5 ^b	43.4 ^b	63.7	51.5 ^c	43.9 ^c
Mother OW	31.0	22.5	34.7 ^b	34.5 ^c	19.6	32.1 ^c	40.1 ^c	23.2	36.4 ^c	48.7 ^c	21.3	34.9 ^c	41.3 ^c
Father OW	57.5	50.9	62.8 ^c	59.6 ^b	47.2	59.5 ^c	63.8 ^c	51.5	61.9 ^c	67.3 ^b	48.5	61.5 ^c	67.9 ^c
Mother OB	8.3	4.1	10.3 ^c	9.9 ^c	2.8	9.0 ^c	12.4 ^c	5.7	10.3 ^c	13.8 ^b	4.6	9.9 ^c	12.2 ^b
Father OB	10.2	5.8	10.5 ^b	12.5 ^c	4.4	11.4 ^c	13.6 ^c	6.7	12.7 ^c	19.9 ^c	5.8	11.3 ^c	20.3 ^c
Child ever breastfed	96.1	97.4	95.1 ^b	95.6 ^b	97.4	96.2	94.5 ^b	97.7	95.4 ^b	94.1 ^b	97.3	96.3	91.1 ^c

Abbreviations: OB, obesity; OW, overweight. ^aReference category. ^bSignificantly different from reference category with $P < 0.05$. ^cSignificantly different from reference category with $P < 0.001$.

Children with high parental and area education level more frequently reported to have eaten breakfast on the day of measurement and drank sugar- and artificially sweetened beverages less often than children with medium and low parental or area education level. Although most children had been breastfed at some point (96.1%), urban children and children with high parental and area education level were more likely to ever have been breastfed. Origin of the children did not differ by urbanization but 32% of children with low maternal education and 16% of children with low paternal education were of non-Nordic origin.

Variables associated with children's overweight and obesity

The association between child and parental weight status is illustrated in Figure 2. Both parents' weight classes were significantly associated with child overweight and obesity. Having an obese mother and a normal weight father was more strongly associated with child obesity than the other way around: OR (95% confidence interval) 9.31 (3.61; 24.03) and 4.26 (1.98; 9.14) respectively, variables adjusted for are the same as presented in Figure 2. There was a positive correlation between children's BMI z-score and mother's and father's BMI; 0.25 ($P < 0.001$) and 0.23 ($P < 0.001$), respectively.

Univariate analyses were performed with each parental determinant and child's lifestyle factor as independent variables with child overweight and obesity as dependent variables. Mother's and father's education were both significantly associated with child overweight and obesity, father's education was, however, more strongly associated with child obesity. Variables with significant associations were included in multivariate analyses (Table 4): variables excluded were gender, sugar-sweetened beverages, breast-feeding, inactivity > 2 h per day, screen time, playing outside and mother's exercise. In the multivariate analyses, associations remained between overweight and medium maternal education, high parental weight status and high consumption of artificially sweetened beverages. When including father's education instead of mother's, significant associations with education disappeared (data not shown). Obesity was associated with high parental weight status, non-Nordic origin and low area education level. Neither mother's nor father's education were significant. There was evidence of effect modification by gender for the urban–rural gradient in obesity, no gradient was observed in girls but a strong one in boys (interaction $P = 0.02$). When performing the multivariate analyses

separately by gender, obesity was associated with parental weight status, non-Nordic origin and consumption of artificially sweetened beverages in girls, while for boys, an association was observed with parental weight status and living area (data not shown).

DISCUSSION

In this nationally representative sample of children, prevalence of overweight in children and their parents was higher in rural compared with urban areas with corresponding differences in some lifestyle factors. Children's and parent's lifestyle and weight status also varied according to parental education and area education level. The urban–rural gradient in overweight was explained by mother's education and parental weight status. The urban–rural gradient in obesity was present among boys only and remained after adjusting for area education level, parental determinants and child's lifestyle. Parental weight status was by far the strongest risk estimate in relation to both child overweight and child obesity.

Overall prevalence of obesity did not differ between girls and boys, whereas the distribution of the prevalence across areas did. For boys, the risk of being obese was several times higher in semi-urban and rural areas compared with urban areas. For girls, the same gradient was not significant in obesity. Boys were reportedly more active than girls, which is consistent with findings in a Canadian study.²³ That study also concluded that boys had a less healthy diet than girls; this could not be confirmed by our study. We observed that boys more often had a TV or computer in their bedroom and also had more screen time than girls. The differences between boys and girls in these lifestyle factors were similar within the areas, which suggest that they cannot explain why the distributions of weight status across areas differ. It may be possible that girls engage in other activities that are not classified as sports or playing outdoors.

Our findings that children in urban areas were less likely to be overweight or obese compared with those in rural areas are consistent with similar findings in Swedish young men.²⁴ Several studies in Italy,⁵ USA²⁵ and Canada⁴ have observed the same differences in children, whereas one study from New Zealand²⁶ observed the lowest prevalence of overweight in rural areas. A reversed gradient has also been found in some countries undergoing economic development,²⁷ which may reflect a shift in living conditions and social environment in the living areas in

Table 3. Child characteristics; in total, by gender, level of urbanization, area education and parental education

	Level of urbanization			Area education			Parental education			
	All	Girls ^a	Boys	Urban ^a	Semi-urban	Rural	High ^a	Medium	Low	>12 years ^a
<i>Child's lifestyle</i>										
Breakfast on the day of study	97.8	98.3	97.2 ^b	98.1	97.1	97.8	98.7	97.5	97.3 ^b	98.6
Sugar-sweetened beverages 4–7 days per week	8.6	8.3	8.8	6.4	10.2	9.3	4.7	9.6 ^b	10.1 ^b	7.3
Artificially sweetened beverages 4–7 days per week	4.4	4.6	4.1	3.2	4.5	5.0	1.7	4.6 ^b	6.5 ^c	3.4
Inactivity > 2 h per day	95.4	95.2	95.5	93.8	96.7 ^b	95.8	95.2	95.2	95.8	95.5
Inactivity > 4 h per day	13.8	12.6	15.0	9.2	16.5 ^b	15.4 ^c	7.9	15.1 ^c	16.6 ^c	9.7
Screen time ≥ 2 h per day	79.5	77.1	81.7 ^b	74.4	80.5 ^b	81.8 ^b	76.6	79.7	81.6 ^b	77.8
TV/computer in bedroom	39.6	35.5	43.6 ^c	35.0	44.5 ^b	40.8 ^b	32.0	41.0 ^c	44.1 ^c	31.1
Member of sports club	77.6	75.1	80.0 ^b	82.0	79.1	74.9	86.2	75.7 ^b	73.5 ^b	84.1
Sports ≥ 3 days per week	21.6	18.0	25.0 ^c	30.8	24.5	16.0 ^c	31.6	20.0 ^b	15.2 ^c	25.1
Playing outside ≥ 2 h per day	62.8	61.0	64.7 ^b	58.3	68.1	63.8 ^b	57.9	64.2	65.0 ^b	56.6
Maternal education										
>12 years ^a	98.4	98.4	98.4	98.6	98.6	98.6	98.6	98.6	98.6	98.6
10–12 years	97.4	97.4	97.4	97.4 ^b	97.4 ^b	97.4 ^b	97.4 ^b	97.4 ^b	97.4 ^b	97.4 ^b
≤9 years	94.8 ^c	94.8 ^c	94.8 ^c	94.8 ^c	94.8 ^c	94.8 ^c	94.8 ^c	94.8 ^c	94.8 ^c	94.8 ^c
Paternal education										
>12 years ^a	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4
10–12 years	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5
≤9 years	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2

^aReference category ^bSignificantly different from reference category with $P < 0.05$ ^cSignificantly different from reference category with $P < 0.001$. **Figure 2.** Percentage and adjusted percentage of overweight and obesity (IOTF) in Swedish 7–9-year-old school children according to parental weight status. There was a positive relationship between parent's and children's weight status that remained after adjusting for several variables. OR for overweight adjusted for urbanization, area education, maternal education, origin, parental weight status, father's exercise, artificially sweetened beverages, breakfast, inactivity > 4 h per day, TV/computer, and sports 3 days per week, OR for obesity adjusted for urbanization, area education, maternal education, origin, parental weight status, father's exercise, artificially sweetened beverages, inactivity > 4 h per day, member of sports club and sports 3 days per week. Crude and adjusted OR (95% confidence interval) is presented in Table 4. (OW: overweight, OB: obesity, pre-OB: pre-obesity, Adj: adjusted.)

these countries. The different findings may reflect differences between countries, but could also originate in a lack of agreement between classifications of urban and rural areas. In Sweden, studies with slightly different classifications have found a similar urban–rural gradient in weight class.^{24,28} The current study observed differences in several variables associated with overweight, which were in line with the urban–rural gradient in children's weight status.

The study from New Zealand²⁶ did not observe any differences in physical activity according to level of urbanization, but there were higher levels of screen time in urban areas. Conversely, in our study, children in urban areas had a lower level of screen time and less total inactivity, they also reported to be exercising more days per week. The Canadian study from 2008⁴ observed the same urban–rural gradient in overweight and obesity as our study, but found that rural children were more active and had less screen time than urban children. That is, the children with highest rates of overweight and obesity also had the highest level of physical activity. This may be attributable to overweight children becoming more active to manage their weight, or as discussed by the authors, it could be caused by overreporting of physical activities. The American study from 2008²⁵ also found that rural children were more active than urban children, mainly because of higher activity during lunch break at school in rural areas. In our study, children from rural areas played outside more than children in urban areas, but they also had more inactive time and participated less in organized sports. In rural areas, children often lack possibilities of active transportation to school and consequently go by car or bus. Apart from possibly being a result of different characteristics of urban and rural areas and transportation systems in the countries, the varying distribution of these lifestyle variables

Table 4. Associations between social factors, parental determinants, lifestyle and children's OW and OB, OR (95%CI)

	OW				OB			
	Univariate model ^a		Multivariate model ^b		Univariate model ^a		Multivariate model ^c	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
<i>Level of urbanization (Urban^d)</i>								
Semi-urban	1.38	0.97; 1.96	0.85	0.56; 1.31	2.46	1.14; 5.29	1.46	0.65; 3.27
Rural	1.82	1.42; 2.35	1.06	0.74; 1.50	2.74	1.46; 5.15	1.28	0.63; 2.62
<i>Area education level (High^d)</i>								
Medium	1.76	1.31; 2.37	1.27	0.81; 1.99	5.64	2.46; 12.92	3.42	1.11; 10.60
Low	2.41	1.78; 3.25	1.46	0.87; 2.45	7.24	3.11; 16.88	3.43	1.07; 10.99
<i>Maternal education (> 12 years^d)</i>								
10–12 years	1.59	1.33; 1.92	1.28	1.01; 1.62	1.48	0.99; 2.22	1.11	0.65; 1.91
≤ 9 years	1.87	1.22; 2.86	1.08	0.64; 1.81	2.25	1.06; 4.78	0.73	0.25; 2.14
<i>Origin parents (Nordic^d)</i>								
Non-Nordic	1.37	0.96; 1.97	1.36	0.97; 1.90	2.11	1.32; 3.39	2.68	1.36; 5.27
<i>Parental weight status (Both NW^d)</i>								
1 NW, 1 pre-OB	1.91	1.49; 2.46	1.68	1.27; 2.22	1.46	0.70; 3.05	1.39	0.63; 3.07
1 NW, 1 OB	3.16	2.06; 4.84	2.75	1.70; 4.43	6.83	3.47; 13.43	5.88	2.94; 11.73
Both pre-OB	3.99	3.03; 5.25	3.41	2.51; 4.63	4.67	2.23; 9.76	3.65	1.61; 8.31
1 pre-OB, 1 OB	5.19	3.64; 7.41	3.73	2.58; 5.38	6.18	2.72; 14.04	3.49	1.37; 8.92
Both OB	9.77	5.54; 17.22	8.96	5.02; 15.99	18.36	7.59; 44.42	14.47	5.77; 36.30
<i>Regular exercise, father (Yes^d)</i>								
No	1.21	1.00; 1.45	1.00	0.81; 1.24	1.46	0.96; 2.20	1.06	0.69; 1.63
<i>Artificially sweetened beverages (0–3 days per week^d)</i>								
4–7 d/w	1.56	1.06; 2.28	1.51	1.03; 2.21	2.23	1.12; 4.44	1.87	0.90; 3.89
<i>Breakfast on the day of study (Yes^d)</i>								
No	2.04	1.24; 3.33	1.72	0.92; 3.21	0.92	0.24; 3.50	—	—
<i>Inactivity (< 4 h per day^d)</i>								
> 4 h per day	1.55	1.25; 1.92	1.20	0.92; 1.58	1.82	1.10; 3.01	0.79	0.42; 1.49
<i>TV/computer in bedroom (Yes^d)</i>								
No	0.74	0.62; 0.90	0.95	0.73; 1.22	0.76	0.52; 1.12	—	—
<i>Sports (< 3 days per week^d)</i>								
≥ 3 days per week	0.77	0.60; 0.99	0.90	0.64; 1.25	0.42	0.22; 0.81	0.75	0.33; 1.67
<i>Member of sports club (Yes^d)</i>								
No	1.09	0.90; 1.32	—	—	1.60	1.06; 2.41	1.33	0.76; 2.33

Abbreviations: CI, confidence interval; OR, odds ratio. ^aUnivariate analyses, linear regression with schools included in model. Variables with significance level of > 0.1 were excluded from further analyses and are not presented in the table (gender, sugar-sweetened beverages, breast-feeding, inactivity > 2 h per day, screen time, playing outside, mother's exercise). ^bMultivariate analysis including variables that were significant for overweight (OW) at a *P*-value < 0.1 in univariate analyses (urbanization, area education, maternal education, origin, parental weight status, father's exercise, artificially sweetened beverages, breakfast, inactivity > 4 h per day, TV/computer, and sports 3 days per week), linear regression with schools included in model, *n* = 2636. ^cMultivariate analysis including all variables that were significant for obesity (OB) at a *P*-value < 0.1 in univariate analyses (urbanization, area education, maternal education, origin, parental weight status, father's exercise, artificially sweetened beverages, inactivity > 4 h per day, member of sports club and sports 3 days per week), linear regression with schools included in model, *n* = 2675. ^dReference.

may be due to that different methods for estimating physical activity/inactivity were used. It would be preferable to use objective methods such as accelerometers to measure activity level.

It is also evident that diet has an important role in developing overweight and obesity. Sugar-sweetened beverage consumption is one of the few dietary factors where evidence of relation to overweight and obesity exists.²⁹ The current study observed higher consumption of sugar-sweetened beverages in rural areas; although it was not statistically significant it was in line with the observed gradient in anthropometry. The Canadian study⁴ did not investigate sugar-sweetened beverages specifically, but found

that children in rural areas had a lower consumption of vegetables and purchased high caloric snacks at school more often than children from urban areas. Consumption of artificially sweetened beverages did not differ between areas but there was an association with overweight and with obesity in girls, which may be caused by overweight children or their parents replacing sugar-sweetened beverages with 'diet products'. The differences in lifestyle factors across areas suggest that interventions should target areas with high risk of less healthy behavior; what defines these areas may differ between countries.

In our sample, there was a higher prevalence of overweight and obesity among children with less-educated parents, a finding

which is consistent with other European studies.^{7,8} Children with less-educated parents also participated in organized sports less often and had a higher level of inactivity, as observed in other Swedish studies in low socioeconomic status areas³⁰ and in children in families with blue collar jobs and low income.³¹ Having two parents of non-Nordic origin was associated with overweight and obesity, which is similar to a regional study in Sweden that found higher prevalence of overweight in a community with high proportion of immigrants.³⁰ Children's BMI was positively associated with parent's BMI, consistent with observations in a regional Swedish study.¹⁴ A recent Australian study³² found that children with overweight or obese fathers had a higher risk of becoming obese than those with an overweight or obese mother. In our study, both parents' weight classes were significantly associated with children's overweight and obesity and having an obese mother and a normal weight father was associated with higher risk than the opposite scenario. When combining both parent's weight classes, there was a strong relationship with their children's weight status, which was also observed in a recent Italian study.³³

Mother's education and parental weight status were associated with child overweight. Area education level, which explained the urban-rural gradient in overweight in our previous study,² was not significant. For obesity in girls and boys combined, area education level was an explanatory factor, as were parental weight status and origin. When performing separate multivariate analyses by gender, area education level was no longer significant in either sex, possibly due to lack of power in the groups. For obesity in boys, living area was still significant together with parental weight status. The fact that none of the lifestyle factors remained significant could be due to difficulties in capturing them correctly and possibly because parental weight status is such a strong determinant. Parents and children share both genes and environment and the key to reaching children at risk of overweight is most likely to target families at risk and finding ways to promote lifestyle changes. Ideally parents should be involved at an early stage, maybe as early as during pregnancy and with young children up to pre-school ages. Identification of such high risk children from the school setting would be more difficult to achieve as school health personnel know little about the parents' weight status. Therefore, in addition to intervening through child health care when children are young, it is also important to work on a geographical basis by targeting children in areas with low education and/or density of population.

A limitation to the current study was the non-participation at school level. However, the remaining sample was still assessed to be representative for Swedish 7-9 year old school children: participating and non participating schools were evenly spread considering geography, type of municipality and area education level.² At child level, 80% of measured children returned the questionnaire, which is relatively high participation in a questionnaire-based study. As we have measured data on a majority of children, and area information on all children, it is possible to analyze the characteristics of those without questionnaires. With the higher prevalence of overweight and obesity among children who failed to return the questionnaire, it is possible that the observed gradients in lifestyle factors would have been even more pronounced if all questionnaires had been returned. Furthermore, the urban-rural gradient in overweight corresponded to the one observed in the total sample² and there was no difference in participation between geographic areas. Another limitation was that we only considered sugar- and artificially-sweetened beverages in our analyses. There might be other important dietary factors that our method did not capture. Important advantages of the current study were that we used measured and standardized data, which to our knowledge has not been done before on a nationally representative Swedish sample of school children. Individual data on lifestyle and socioeconomic

factors were available for both children and parents and we also gathered information about parent's weight status, even though these data were self-reported and thereby could be biased. This comprehensive data collection allows us to study children's lifestyle and anthropometry in relation to urbanization, socioeconomic factors, parental BMI and lifestyle. Other studies have also investigated possible causes of urban-rural differences in weight class, but some are based on self-reported anthropometric data^{3,6} and others lack access to lifestyle data⁵ and parental data.^{5,25,26} Finally, it is important to note that the survey was harmonized with the WHO COSI, making future pan-European comparisons possible.

In conclusion, both area factors and individual characteristics influenced children's weight status. Parent's weight status was the absolute strongest determinant for children's weight status, indicating that actions need to be taken on different levels. Living area, as well as social position determine which lifestyle choices are made and influence both adults' and children's weight status. To be able to target children with the highest risk of overweight and obesity, it is important to monitor family weight status whenever possible. It might, however, be more effective to target high risk areas where we find the highest proportion of overweight and obesity among both children and their parents.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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