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Increasing social disparities in obesity among 15 000 pre-schoolers in a German district from 2009 to 2019

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Background: Although childhood obesity prevalence has stagnated in many high-income regions after decades of increase, it continues to be a major public health problem with adverse effects. The objective was to examine obesity trends as a function of parental social status to identify obesity disparities among children. **Methods:** Data from school entry examinations from 2009 to 2019 of 14 952 pre-schoolers in one German district were used. Logistic regression models (obesity/overweight as dependent variable) and a linear regression [BMI *z*-score (BMIz) as dependent variable] were performed adjusted for social status and sex to investigate time trends in overweight and obesity. **Results:** Overall, we found an increase of obesity over time [odds ratio (ORs): 1.03 per year, 95% CI: 1.01–1.06]. Children with low social status had an OR of 1.08 per year (95% CI: 1.03–1.13), while the trend was less expressed in children with high social status (OR: 1.03 per year, 95% CI: 0.98–1.08). The mean BMIz decreased per year (regression coefficient −0.005 per year, 95% CI: −0.01 to 0.0) when considering all children. This decrease was more pronounced in children with high social status (regression coefficient: −0.011 per year, 95% CI: −0.019 to −0.004), compared with a slight increase of 0.014 (95% CI: −0.003 to 0.03) per year among children with low social status. Also, children with low parental social status were heavier and smaller than their peers with high social status. **Conclusions:** Although the mean BMIz decreased among pre-schoolers, obesity prevalence and status-related inequity in obesity prevalence increased from 2009 to 2019 in the region studied.

Introduction

Childhood obesity is a major public health concern with 39 million children under five affected worldwide in 2020, and over 124 million children and adolescents from 5 to 19 years in 2016.[1] Studies showed that children with obesity and particularly adolescents with obesity are more likely to be obese as adults.[2] Childhood obesity is also related to a large variety of health disorders in adulthood including high blood pressure, atherosclerosis, dyslipidaemia, type 2 diabetes, asthma, gastroesophageal reflux and others.[3,4]

In the past decades, the obesity prevalence increased in most low-income countries as well as in high-income countries.[1,4–6] In a German study analyzing data from children between the ages 4 and 16 years ($N = 272\,826$), a clear upwards trend of overweight and obesity was observed between 1999 and 2003 while from 2004 to 2008 the prevalence stabilized at a high level in most age subgroups. In the age group from 4 to under 8 years, a downward trend was found.[7] Other studies also demonstrated a stagnation or even a decrease in obesity prevalence in children in high-income countries in recent years.[8–11]

Still, there are indications that these trends do not affect all children equally. In cross-sectional studies, parental socioeconomic status and education have been shown to be predominantly inversely related to child weight in high-income countries.[12] This relationship is influenced by factors such as parental obesity, early weaning of breast feeding, food intake patterns and physical inactivity.[13] There are studies analyzing trends over time that indicate differences in obesity prevalence trends according to family income[14] and socioeconomic status.[15]

In Germany, female sex,[16] parental smoking,[16] lower parental education[16] and parental body mass index (BMI),[17] high birthweight,[16] lack of breastfeeding[18] and non-German citizenship[16] have also been found to be associated with obesity risk in various samples of children and adolescents.

Despite an increase in scientific interest in the last years, the influence of social status on time trends in childhood obesity in Germany has not been analyzed sufficiently yet.

Aim of the study

The objective of this study was to examine childhood obesity and overweight trends over a period of 11 years as a function of parental social status, using the example of Saale district in Saxony-Anhalt.

Methods

This is an exploratory analysis of secondary data from school examinations that were collected in Saale district, Germany, from 2009 to 2019.

Preliminary considerations

In Saxony-Anhalt, examinations in schools carried out by the health offices have a long tradition and the data collected in these

examinations is an important base for health reporting. Of the three school examinations, the school entry examination (SEE) is the only school examination that is mandatory and therefore covers all children starting school in Germany. It takes place the year before the planned school enrolment.[19]

Further school examinations are conducted in the third and sixth grades. In those examinations, medical staff visits the schools and examines the children present on the respective day. Compared with the SEEs, information gathered in these examinations is more limited, e.g. no information on the child's social environment is collected. Moreover, due to a shortage of doctors in our study district, not all children were physically examined, therefore the data are less extensive compared with the SEE.

Data

The local health authority of the Saale district provided anonymized datasets from the years 2009 to 2019. The data analyzed were exported each year after a specific period in which the main survey took place. Children who did not show up for SEE on the scheduled date and who received appointments shortly before enrolment were not included.

The data we received from the health authority contained information on each child's age and sex, their weight and height at each examination and the date of the examination. For the school entry examination, in addition to the afore-mentioned variables, we have information on father's and mother's education (measured in three categories: <10 years, 10 years and >10 years) and their respective employment status (employed or unemployed). Based on these variables, we calculated a score for each child's social status (see below).[19]

In order to achieve more concise age groups, only 4–6-year-old children were included in the analysis from the SEE data set, 8–10-year-old children in the third grade, and 11–13-year-old children were included in the sixth grade.

The data set of each year contains cross-sectional information on children 1 year before school enrolment, children in third grade and children in sixth grade. Due to reasons of data protection, we were not able to connect the data on the same child over the years. Therefore, the calculated time trends do not follow children individually but represent a series of cross-sections.

Social status

To describe the social status, the Brandenburg Social Index was used, which is a tool that is routinely utilized in Germany to quantify the social status of a child based on information of SEEs.[20] In a parent questionnaire, information on the parents' education (one point for <10 years/two points for 10 years/three points for >10 years of schooling) and current employment status (one point for employed/two points for unemployed) is reported. If information on one parent is missing, the score of the reported parent doubled.[20] Using this information, the Brandenburg Social Index was calculated and each child was assigned a low (4–6 points), middle (7–8 points) or high (9–10 points) social status. The Brandenburg Social Index does not distinguish between full-time and part-time employment and no information on income or higher education is collected. The Brandenburg Social Index is here referred to as the child's social status.

Information on the health status

Height and weight were measured by medical assistants. The BMI was calculated automatically by the software used by the Public Health Department and the age- and sex-specific BMI percentile was automatically determined from percentile curves of a German reference population.[21] Underweight is defined as <10th percentile of the reference population, normal weight as 10th to 90th percentile, overweight as >90th to 97th percentile and obesity as >97th percentile.[21]

Whereas the analysis of obesity and overweight prevalence gives information on the upper end of the BMI distribution, we also wanted to analyze the central tendency of the BMI trends. To derive such an estimate for general weight trend (and not only overweight or obese children), we performed a *z*-transformation of BMI. Hereby, we calculated age- and sex-specific standard deviation scores (*z*-scores, here referred to as BMIz) based on our study population (all study years combined) for 4-, 5- and 6-year-old girls and boys, respectively. Thus, BMIz was calculated for each child using the child's BMI and the BMI mean and standard deviation in the according 1-year age- and sex-group.

Statistical analyses

The statistical analyses were performed using SAS Studio. First, we calculated the prevalence with the respective 95% confidence intervals of overweight including obesity by year of examination for the SEE, the examination in the third grade and the examination in the sixth grade.

Using data from the school entry examination that includes information on the children's social status, we then conducted two separate analyses to investigate trends over time for each social status group.

Children with missing data on social status were not included in the analyses.

Hereby, we first performed a logistic regression with obesity as dependent variable ('obese vs. not obese') and calendar year, sex and social status as independent variables. In a next step, a similar analysis was conducted for the dependent variable 'obese or overweight (vs. neither obese nor overweight)'. When analyzing the interaction of the calendar year and social status in these models, we observed an effect. Therefore, we performed an analysis stratified by social status for both independent variables with calendar year and sex as the dependent variables. The odds ratios obtained as a result refer to the 1-year increase and are referred to in this article as the odds ratio per year.

In a second analytical approach, we performed a linear regression with calendar year, sex and social status as independent variables and BMIz as dependent variable and analyzed the interaction of the calendar year and social status as well. Similar to the first analytical approach, as the interaction models showed interaction of time and social status, a stratified analysis by social status was performed with calendar year and sex as dependent variable and BMIz as independent variable.

The presented regression coefficients can be interpreted as change in the mean BMIz per year, whereby a higher BMIz means a higher BMI compared with the average of children of the same sex and age. By this, we were able to analyze the central tendency of the BMI distribution whereas the analysis of obesity and overweight prevalence in the first analytical approach gives information on its upper end.

To address the problem that the social status of single parents is overestimated by the Brandenburg Social Index (because if there is no information on one parent, the points of the other parent are automatically doubled), we conducted the same analyses stratified by social status, including only children with information on both parents. We also conducted the analyses stratified by the parents' education (both parents' points for education added, only children with information on both parents included).

Ethics approval

The use of anonymized data from school examinations was approved by the local ethics committee at Martin Luther University Halle-Wittenberg (processing number: 2021-011).

Results

Sociodemographic characteristics of the study population

The whole data set contained data of 14 952 children (mean age: 5.09 years) in the SEE, 12 910 in the third grade (mean age: 8.7 years) and 10 762 in the sixth grade (mean age: 11.8 years). Further demographic characteristics of the study cohorts are shown in table 1.

Prevalence of overweight and obesity in the three examinations and by social status

The prevalence of obesity and overweight increased with the age of children from the SEE through grade three to grade six (overweight excl. obesity: from 7.9% to 12.2% to 14.7%, obesity: from 6.9% to 9.4% to 11.8% and overweight incl. obesity: 13.8% to 21.6% to 26.5%). This is visualized in figure 1 over the years from 2009 to 2019.

In the SEE, stratification by social status showed that of all children with high social status 3.5% were obese, compared with 6.7% with middle and 9.4% with low social status. Considering overweight and obesity, prevalence was 9.6% among children with high social status, 15.5% among children with middle social status and 18.5% among children with low social status. In figure 2, the prevalence of obesity in the SEE by social status is visualized over time.

Interaction model

The interaction models of the multivariable logistic regression with the dependent variables 'obese' and 'obese or overweight' as dependent variable, respectively, showed an interaction of social status and time [odds radio: 1.03 (95% CI: 0.98–1.08) per year for children with high social status and 1.08 (95% CI: 1.03–1.13) for those with low social status for 'obesity' and 1.00 (95% CI: 0.97–1.03) and 1.04 (95% CI: 1.00–1.08) for those groups for 'overweight and obesity'].

The same was the case in the multivariable linear regression with the dependent variable BMIz [regression coefficient: 0.026 (95% CI: 0.01–0.04) for children with low social status when those with high social status as reference group]. Therefore, logistic and linear regression was performed stratified by social status. The results are presented in the following sections.

Sex was not associated with differences in BMI in our cohort. The OR for boys compared with girls was 1.08 (95% CI: 0.94–1.24) for obesity and 0.94 (95% CI: 0.86–1.04) for overweight and obesity.

Time trends in overweight and obesity over the years of examinations

For the SEE, the time trend analyzed in the logistic regression shows that obesity increased over the years of examination (OR per year: 1.03, 95% CI: 1.01–1.06), while the OR per year for overweight and obesity together was 1.01 (95% CI: 0.99–1.02).

For obesity alone, logistic regression showed an OR of 1.03 (95% CI: 0.98–1.08) per year for children with a high social status, OR = 1.05 (95% CI: 1.02–1.08) for those with middle social status and OR = 1.08 (95% CI: 1.03–1.13) for children with low social status. For overweight and obesity, logistic regression shows no increase over the years (OR per year: 1.01, 95% CI: 0.99–1.02). When stratified by social status, children with high social status have an OR per year of 1.00 (95% CI: 0.97–1.03), children with middle social status of 1.02 (95% CI: 1.00–1.04) and those with low social status 1.04 (95% CI: 1.00–1.08). More details are found in table 2.

Another variable that showed differences according to the child's social status is height. The mean height of children with high social status at the time of the SEE was 116.3 cm (95% CI: 116.1–116.4), of those with middle social status 115.8 cm (95% CI: 115.7–116.0) and of children with low social status 114.7 cm (95% CI: 114.5–115). Between those with low and high social status, there was a mean height difference of 1.6 cm.

Time trends of the central BMI-tendency analyzed by BMIz

Considering all children aged 4–6 years, the regression coefficient for the association between time and BMIz was −0.005 (95% CI: −0.01 to 0.0).

In the subgroup with a high social status, the regression coefficient/year was −0.011 (95% CI: −0.019 to −0.004) and a mean BMIz of −0.1 was found. In comparison, the subgroup of children with low social status has a coefficient/year of 0.014 (95% CI: −0.003 to 0.03) and a mean BMIz of 0.2. Regression coefficients from the linear regression are shown in table 2. Mean values for BMIz, BMI, height and weight stratified by social status and weight group are found in Supplementary 2.

Additional analyses (on the subgroup including only children with information on both parents' education and employment) stratified by social status can be found in Supplementary 3 and by parental education in Supplementary 4.

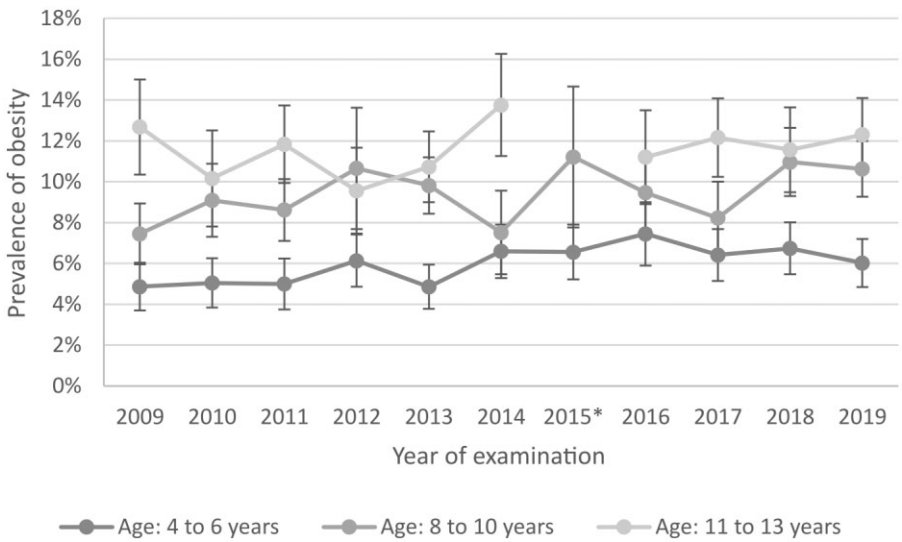

Figure 1 Prevalence of obesity by age groups (whiskers indicate 95% confidence intervals of the estimates): the prevalence of obesity increases with age. *No data available in sixth grade and less in fifth grade due to shortage of doctors

Table 1 Sociodemographic characteristics of the study population

	SEE			Third grade			Sixth grade	
	N	%		*N*	%		*N*	%
Total	14 952			12910			10762	
Sex								
Male	7667	51.3		6592	51.1		5520	51.3
Female	7285	48.7		6318	48.9		5242	48.7
Age								
<4	2	0.01	<7	1	0.01	<10	8	0.1
4	935	6.3	7	37	0.3	10	25	0.2
5	12 206	81.7	8	5139	39.8	11	3358	31.2
6	1798	12.0	9	6702	51.9	12	6302	58.6
>6	11	0.1	10	884	6.9	13	957	8.9
			>10	147	1.1	>13	112	1.0
Social status[a]								
High	4657	31.2						
Middle	6807	45.5						
Low	1922	12.9						
Missing data	1566	10.5						
Number of siblings								
<3	13 775	92.1		11854	91.8		9769	90.8
≥3	1177	7.9		1056	8.2		993	9.2
Paediatric routine checkups								
Complete	9740	65.1						
Incomplete	3918	26.2						
Missing data	1294	8.7						
Height								
Mean (cm)		115.7			137.7			156.3
SD		6.8			7.1			8.2
Weight								
Mean (kg)		21.5			34.4			50.6
SD		4.0			8.6			13.3
BMI								
Mean (in kg m^{-2})		15.9			18.0			20.5
SD		2.1			3.3			4.2
Weight status								
Underweight	1024	6.9		793	6.1		663	6.2
Normal weight	11 794	78.9		9189	71.2		7216	67.1
Overweight	1174	7.9		1571	12.2		1582	14.7
Obesity	886	5.9		1216	9.4		1265	11.8
Missing data	74	0.5		141	1.1		36	0.3

a: According to Brandenburg Social Index.

Discussion

In this study, we found that even though the mean BMIz of all examined children decreased between 2009 and 2019, the obesity prevalence still increased slightly. Notably, there were differences in the prevalence of overweight and obesity depending on the social status, while compared with the average German obesity prevalence, we found a comparably high overall prevalence.[22]

The same holds true for changes in the prevalence over time. Children with low social status were smaller and heavier compared with children with high social status, and BMI differences between these groups increased slightly over time, both in obesity prevalence and in mean BMIz.

These findings align with the previous literature: in most high-income countries, prevalence of obesity in children stagnated or even decreased recently.[7–11,23] Still, studies show that despite the overall stagnation or decline, socioeconomic disparities in child obesity widened.[14,15,24–26]

Regionally, in some areas of Saxony-Anhalt, an increase of overweight including obesity in the years 1991–2005 (OR: 1.025 per year, 95% CI: 1.012–1.038) was reported among pre-schoolers, while from 2008 to 2014, the prevalence was almost stable.[27] With respect to social status, it has recently been shown that the increase in adult obesity in Germany is mainly due to increasing obesity prevalence in low and middle socioeconomic groups.[28] As our study and others show, the link between socioeconomic status and weight already exists starting from young age.[29]

This raises the question of the cause of this occurrence. The association between socioeconomic status and overweight or obesity prevalence is well-established.[12] This is due to different mechanisms, not all of which are yet understood in detail. For example, it was shown that children (age 6–18) with low social status are less often members of sports clubs than children with high social status (36.2% vs. 66.8%), spend less time per week on exercise in sports clubs (means 38 vs. 69 min) and spend more time watching TV (means 91.9 vs. 58.7 min day^{-1}).[30] Children with a low social status also consume white bread, salted snacks and soft drinks more often. Fruits are consumed less often in this group.[30] Further, it was shown that the quality of breakfast is related to SES and that a lower breakfast quality has a positive association with BMI.[31] Economic and educational disadvantages are also likely to impact various health-related behaviours.[32]

But not all risk factors are only behavioural: reviews also showed earlier weaning of breastfeeding is more prevalent in lower socioeconomic groups and seems to increase the child's risk for obesity.[13] Maternal smoking during pregnancy, less access to healthy nutrition and safe exercise options increases the risk of obesity as well.[16,33] A Canadian study showed that a high density of fast food and convenience stores is associated with less healthy diet among participants.[34]

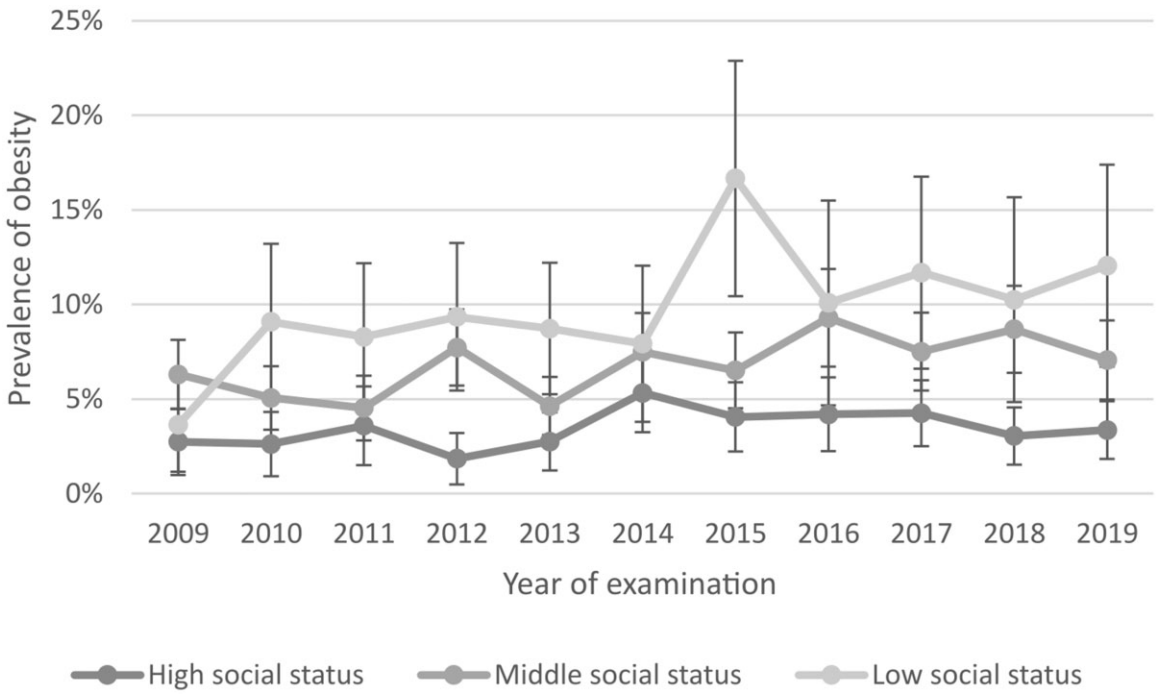

Figure 2 Prevalence of obesity in 4–6-year-old children by social status (whiskers indicate 95% confidence intervals of the estimates): children with low social status have the highest prevalence of obesity and their prevalence increases over the years

Table 2 Results of the logistic regression and the linear regression with the independent variable calendar year stratified by social status, adjusted for sex

	Logistic regression Dependent variable: obesity Odds ratio per year (95% CI)	Logistic regression Dependent variable: overweight and obesity Odds ratio per year (95% CI)	Linear regression Dependent variable: BMIz Regression coefficient per year (95% CI)
All	1.03 (1.01–1.06)	1.01 (0.99–1.02)	−0.005 (−0.01 to 0.0)
High	1.03 (0.98–1.08)	1.00 (0.97–1.03)	−0.011 (−0.019 to −0.004)
Middle	1.05 (1.02–1.08)	1.02 (1.00–1.04)	0.001 (−0.007 to 0.009)
Low	1.08 (1.03–1.13)	1.04 (1.00–1.08)	0.014 (−0.003 to 0.03)

The root causes for the increasing obesity prevalence in children with low social status relative to those with high social status are not yet well understood and not extensively investigated. On the way towards health equity, this is an important issue as childhood overweight and obesity increase the risk for many diseases both in childhood and adulthood. An understanding of this development is therefore crucial to addressing not only child obesity but also the health inequities it creates. Only if the causes and influencing factors are better understood can effective prevention be made possible that also reach those at risk.

Strengths and limitations

Even though the SEE is mandatory for school enrolment, it has to be mentioned that children who did not show up in the check-up voluntarily might have been missed, since they are sometimes given a second appointment shortly before school enrolment and were then not included in our data. Another limitation concerns the assignment of social status: The Brandenburg Social Index is a rather vague instrument to estimate the socioeconomic environment of a child, as important factors—namely income, part-time employment or higher education—are not included[20] and single parents' social status is overestimated by doubling this parent's points. Unfortunately, the use of secondary data from school examinations implies the limitation of having limited information on the participants; we think that this disadvantage is outweighed by the advantage of having a very large dataset with almost complete birth cohorts of children. This is one of the strengths of this study and allows for an analysis of time trends over the 11-year period.

The combination of two methods—examining obesity prevalence as well as mean BMI *z*-scores over time—provided a better understanding of weight trends in this population. Another strength is the stratification by social status in the analyses of the time trends. This aspect has not been sufficiently studied before and provides additional information on the distribution of the generally favourable trend we found.

Practical implications

Although interventions are beyond the scope of this article, the findings indicate the need for interventions that address not only childhood obesity in general but also social inequalities in childhood obesity. Because childhood obesity is an important risk factor for obesity and chronic diseases in adulthood,[3] prevention that targets social disparities in obesity is an important step towards health equity.

Therefore, understanding how interventions impact children across the socioeconomic spectrum is essential for effective prevention. One important problem is that despite the large number of

reports on obesity prevention interventions, few examine the impact on children with different socioeconomic status.[35]

Some studies indicate that information-based interventions are less effective for children with lower socioeconomic status.[36] A randomized controlled trial showed for instance that motivational interviewing was effective in BMI control for children between 4 and 7 years, but had less effect in treating overweight in children whose mothers' education was low.[37]

In contrast to that, interventions that include community-based and structural change are more effective across the social spectrum.[38] Especially multilevel and multisetting are promising, as they can increase physical activity and improve nutrition through multiple initiatives in different settings, including the home, schools and the broader community.[39]

The 'Shape Up Somerville' study, for example, used a multilevel and community based approach for its intervention: By engaging the whole community, multiple social determinants of children's health were addressed, including healthier foods in schools, increased physical activity through walking-to-school-initiatives, additional classroom activities, after-school programs and training of health care professionals on childhood obesity and its screening. Also community-wide policies have been put in place, e.g. to promote healthier foods and improve pedestrian friendliness. In result, this intervention led to a decrease of BMIz in children at risk of obesity.[40]

Conclusions

The combination of targeted and community-wide interventions can help reduce obesity and meet the needs of children at risk of obesity, especially those with fewer resources.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Author contributions

Z.M., N.K., A.W. and A.F. contributed to conceptualization. Z.M., A.W., A.F. and R.M. contributed to methodology. Z.M. contributed to data curation. Z.M. and A.F. contributed to formal analysis. A.W. and R.M. contributed to resources. Z.M. contributed to writing—original draft. N.K., K.G., A.W., A.F. and R.M. contributed to writing—review and editing. A.F., A.W. and R.M. contributed to supervision. A.F. contributed to project administration. All authors have read and agreed to the published version of the manuscript.

Data availability statement

The data that support the findings of this study are available from the Department of Public Health, Saalekreis, Germany (address: Gesundheitsamt, Oberaltenburg 4b, 06217 Merseburg, Germany), but restrictions apply to the availability of these data, which were used under license for the current study and therefore are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of the Department of Public Health, Saalekreis, Germany.

Key points

- This is the first study to analyze trends in childhood obesity by social status using data from school entry examinations in Germany.
- Overall, there was a slight increase of obesity over the observation period.
- Children with low social status consistently showed a higher prevalence of obesity compared with their peers with high social status. In addition, they also showed a substantial increase in obesity from 2009 to 2019, while for children with high social status the obesity prevalence remained stable.

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