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Spatial differences in childhood and adolescent obesity according to sex and migrant status in Vienna, Austria

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Abstract

Background The marked spatial differences in the prevalence of childhood overweight/obesity rates within cities are mainly due to environmental characteristics of individual intracity areas. This is the first analysis of spatial differences in the prevalence of overweight/obesity among children in the Austrian capital Vienna.

Subjects and methods In the medical-record-based study, the weight status of 1611 Viennese school children of lower socioeconomic backgrounds at the ages of six, ten, and 15 years from 46 randomly selected public secondary schools were included. Medical data have been obtained at schools by trained members of the Medical school authority. Besides effects of sex and background of migration, associations between weight status and the natural as well as social environments of the residential and school districts were analyzed. Since the 23 political districts of Vienna differ markedly in socioeconomic and environmental characteristics, a comparison between the districts was carried out.

Results Especially high overweight and obesity rates were found for the socially disadvantaged areas of the 10th, 12th, and 15th political district of Vienna. Children living and attending schools in better-off districts had lower rates of overweight and obesity, despite their low social status. The most important factors influencing overweight and obesity were parameters of the social environment and characteristics of the residential area of the children. Significant associations between the body mass index and unemployment rates, average monthly income, the educational level of the district population, the proportion of migrants in the district, and sociodemographic cluster areas could be observed. This was equally true for girls and boys, as well as children with or without a migrant background.

Conclusion In general, socially disadvantaged, inner-city areas showed extremely high prevalence rates of obesity.

Take home message for students Cities are not homogeneous environments. There are marked spatial differences in the social and natural environment. This is also true of the Austrian capital Vienna. Overweight/obesity rates vary significantly between the different areas of the city. The social characteristics of an area are significantly related to the risk of developing overweight or obesity during childhood and adolescence.

Introduction

The worldwide prevalence of obesity nearly tripled during the last 50 years (Blüher, 2019). Currently, more than 1.9 billion adults (18 years) are overweight (BMI > 25.00 kg/m2) and among these, 650 million are classified as obese (BMI > 30.00 kg/m2) (WHO, 2021). Obesity is not only a problem for the adult population. According to the World Health Organization (WHO, 2021), more than 340 million children and adolescents aged 5–19 years are overweight or obese worldwide (Lasserre et al. 2007). Unfortunately, obesity and overweight not only cause aesthetic problems, but several non-communicable diseases, such as type 2 diabetes, cardiovascular diseases, cancer, respiratory diseases, asthma impaired reproductive function, and psychological distress are also more frequently found among obese people (Clark and Brancati, 2000; Felisbino-Mendes et al., 2020; Shen et al., 2019). Furthermore, obesity weakens the immune system and enhances inflammation and as a consequence, obese individuals are more susceptible to infectious diseases (Pugliese et al., 2022). In the case of SARS COVID 19, obesity increases the risk of both COVID-19-related hospitalization and death (Sawadogo et al., 2022). Being overweight, and obese are also significantly associated with long-term psychosocial and economic problems on an individual level (Ford and Mokdad, 2008; Wang et al., 2011). This is not only true of adults but also of children and adolescents (Ebbeling et al., 2002; Han et al., 2010; Kimm and Obarzanek, 2002; Spinelli et al., 2019). Therefore, the high prevalence of excessive body weight worldwide is a matter of concern because it represents an enormous economic burden on public health and social systems (Withrow and Alter, 2011). In this way, obesity is one of the major worldwide public health challenges of the 21st century (Chooi et al., 2019; Spinelli et al. 2019).

To prevent obesity and to develop strategies to cope with high obesity rates, it is necessary to analyze all factors promoting overweight and obesity. Besides a genetic component which may contribute to 40–70% of obesity (Chiurazzi et al. 2020; Thaker 2017) and intrauterine programming (Fernandez-Twinn et al. 2019) the basic drivers of obesity, are behavioral ones, such as diet, energy supply, adverse eating habits, and a lack of physical activity. These behavioral factors may have a genetic basis, but first of all, they are influenced by environmental parameters. The main environmental reason for rising obesity rates worldwide is the dramatic increase of the so-called obesogenic environment (Hobbs and Radley, 2020), which is mainly characterized as "an environment that promotes gaining weight and one that is not conducive to weight loss" within the home or workplace (Swinburn et al., 1999). The main characteristics of an obesogenic environment are, therefore, conditions that reduce physical activity and enhance adverse dietary patterns such as the consumption of cheap food rich in fat and sugar as well as social neighborhoods that are unsafe and stressful (Lieberman, 2006). Although this kind of environment is often associated with socially disadvantaged areas, obesogenic conditions can equally be found in middle-class suburban areas with low connectivity and a high dependence of car use (Congdon, 2019). Obesogenic environments are consequently determined by social as well as geographical factors.

The impact of environmental factors on the risk of becoming overweight or obese has increasingly gotten into focus during the last 20 years, with special attention paid to urban-rural differences in the prevalence of overweight and obesity (Dong et al., 2019; Hu et al., 2020). In low- and middle-income countries, first of all, an increase in

obesity rates in rural areas can be observed (Dong et al., 2019). This trend is mainly due to nutritional and developmental assistance programs in rural areas of poor countries, but also due to the expansion of obesogenic environments from urban to rural areas (Khan and Krämer, 2014; Mou et al., 2013; Paciorek et al., 2013).

Furthermore, urbanization is an ongoing phenomenon worldwide and is associated with rising obesity rates. Cities, however, are not per se obesogenic environments. It is important to state, that urban areas are not homogenous, but have marked social and environmental differences between intra-urban regions, individual districts, and also within districts. Only a few studies have considered intra-city, spatial differences in obesogenic environments (Dahly et al., 2013; Lakes and Burkart, 2016; Ouédraogo et al., 2008; Penney et al., 2014; Sun et al., 2020). In general, an association between social and environmental factors and the risk of obesity has been documented (Sun et al., 2020). Areas with a low socioeconomic status, characterized by a high amount of poverty and unemployment are considered to promote high overweight and obesity rates.

In the case of childhood overweight and obesity, Lakes and Burkart (2016) showed a distinct spatial distribution of overweight among 5 to 6 year old children in Berlin. Particularly high rates of overweight among these children were found for the inner city, while the suburban areas were characterized by significantly lower prevalence of childhood obesity (Lakes and Burkart, 2016). This spatial pattern in childhood obesity prevalence is interpreted as a result of socioeconomic inequalities between the different areas, because a strong connection between socioeconomic status as well as the social environment and obesity have been reported by several authors (Lobstein et al., 2004; McLaren, 2007; Peeters and Backholer, 2014; Sun et al., 2020). The analysis of spatial or regional differences in the risk of becoming overweight or obese within cities is of special importance for health-oriented spatial planning and developing strategies to avoid increasing obesity rates in urban areas. Unfortunately, up to now, no comparable analysis exists for the Austrian capital Vienna. Therefore, the aim of this study is to analyze the intraurban spatial patterns of overweight and obesity during childhood and adolescence in Vienna and to identify possible influencing factors. In particular, the following two hypotheses were tested.

1. The prevalence of overweight and obesity among children and adolescents differs between individual Viennese districts.
2. The prevalence of overweight and obesity is associated with sex and migrant status, but also with socioeconomic and environmental factors typical for the individual districts, such as unemployment rate, educational level, proportion of immigrants, population density or green areas.

Material and methods

Study design

The present study is a small part of a collaborative project between the University Clinic for Pediatrics, Medical University of Vienna, the Department for Evolutionary Anthropology, University of Vienna and the Viennese Medical School Authority starting in 1999. The data were collected between 1999 and 2008. The aim of the project was the analysis of changing weight status of Viennese children and adolescents between 6 and 15 years, i.e. during compulsory schooling. The longitudinal study based on medical records started at

school entry, usually at the age of 6 years and ended 9 years later, when compulsory schooling ended. In Vienna, public school students are obliged to attend a school that is geographically close to their place of residence. School and place of residence are therefore usually in the same district or at a short distance. This fact is important for spatial analysis. For data protection reasons, body height, body weight, and few sociodemographic data (sex, background of migration, district of residence) were provided in an anonymous data file by the Viennese Medical School Authority.

Study area

Exclusively Viennese children were included in the project and consequently in the present study. Vienna, the Austrian capital had about 1.8 million inhabitants at the time of data collection and, currently, has 1.9 million inhabitants. It is characterized by a highly heterogeneous structure in terms of residential living environments and socio-economics. The urban structure varies widely across the 23 political districts, and includes densely populated areas in the city center, as well as single family homes in the suburban areas. The outskirts are characterized by agriculturally used areas and small villages. About 47% of inhabitants have a migrantion background. Currently, 55% of children aged between 6 and 16 years do not speak German at home. Although the huge migration wave started in 2015, Vienna has been a melting pot of nations since the 1990s and has a multi-ethnic character.

Data set

In our study we analyzed a record-based medical dataset provided by the Viennese School authority. Forty-four public secondary schools (two from each of the 23 districts of Vienna, with the exception of the sixth district) were randomly selected from this Authority. All data originated from public (state) secondary schools, so-called Hauptschulen. Attendance at a public secondary school is an indicator of a quite low social status in Vienna. In Austria, it is obligatory that – beside medical data – the body height and body weight of all school children are collected by specially trained personnel from the medical school authority. Our data set included exclusively body weight and body height data collected by members of the Medical school authority in the schools. The data file, including all information on body height and body weight, are stored by the Viennese school medical office. As pointed out above, the Medical School Authority provided us with anonymized data sets. In the present study we included data from 1611 children, 772 girls and 839 boys.
The following strict inclusion criteria were defined:

a) complete data set (data collection at the ages of 6,10 and 15 years).
b) living in the same district during these 9 years.

Individual data

We obtained limited individual data for each participant. Beside age and sex, there was information regarding the school district, residence area and history of migration for each child defined as being born in a country other than Austria and migrated to Austria for permanent residence, or where at least one parent was born in a country other than Austria. Unfortunately, no information regarding menarche, or parental parameters was available.

Weight status

Data concerning body height (in cm) and body weight (in kg) was provided by the Viennese Medical School Authority from which the body mass index (BMI) (kg/m^2) was calculated. The weight status at the age of 6, 10 and 15 years old was classified as percentiles published by Kromeyer-Hauschild et al. (2001) and Rosario et al. (2010). We are aware, that these German charts may be suboptimal for a multiethnic Austrian sample (Kirchengast and Schober, 2009), however, currently no validated Austrian charts exist. The charts published by Kromeyer-Hauschild et al. (2001) are still used for the Austrian Nutritional Survey. Therefore, we decided to use the Kromeyer-Hauschild charts in this study. A BMI above the sex- and age-specific 90th percentile was defined as overweight, and above the age and sex specific 97th percentile was defined as obese. In the present study, we included all BMIs above the 90th percentile in one group, comprising obesity and overweight.

Sociodemographic and environmental factors

In order to examine the influence of the social and natural environments on weight status, we included the following parameters using the official sources of the Statistical Department of the Viennese Government (Stadt Wien, Wirtschaft, Arbeit und Statistik, 2020):

- green areas for each political district (in hectares)
- population density for each political district (people per km2)
- average monthly income (in €) for full-time job for each political district
- life expectancy for each political district
- mean age of population for each political district
- rate of population with University degree for each political district
- rate of population with mandatory education only for each political district
- unemployment rate for each political district
- migrant rate for each political district

In addition, we used the seven cluster areas of Vienna provided by the Viennese Government (Gemeinde Wien, 2013). These seven cluster areas have been defined by a governmental working group based on the results of a principal component analysis including 29 sociodemographic indicators. The cluster areas describe sociodemographic characteristics of the residential areas of the city of Vienna and correspond to the characteristics of the political districts. Since the sociodemographic structure of some political districts is quite similar, each of the 23 political districts can be assigned to one of 7 cluster areas. A summary of the sociodemographic indicators of the 7 cluster areas is presented in Table 1.

Spatial analyses

In order to compare overweight and obesity rates between individual Viennese districts, we performed a spatial data analysis. We exported a data query of classified percent shares for every Viennese district (except for the 6th district, where no data was available for this study) from IBM SPSS to XLSX file format. For the spatial data analysis, we loaded a structured table containing the anthropological data and ESRI Shapefiles providing spatial information on Vienna (Stadt Wien, 2021, 2020), into the free and open-source geographic information system software QGIS. As a coordinate reference system, we used EPSG:31256 MGI / Austria GK East. For geostatistic analysis and mapping, we applied ‘natural breaks’

Table 1 Characterization of the 7 cluster areas in Vienna.(source: (Gemeinde Wien, 2013))

	fluctuation	unemployment rate	poverty	migration rate	educational level	% of children
Cluster 1	low	very low	very low	very low	high	Low
Cluster 2	low	very low	very low	very low	high	High
Cluster 3	high	very low	very low	low	high	Low
Cluster 4	high	very high	high	very high	low	High
Cluster 5	low	high	medium	medium	low	Medium
Cluster 6	low	low	low	low	medium	Low
Cluster 7	low	high	high	high	low	High

after Jenks (de Smith et al., 2021; Jenks and Caspall, 1971) in order to cluster the percent share of children per district. We then manually defined breaks to classify the anthropological dataset.

Statistical analyses

Statistical analyses were carried out using SPSS for Windows (version 27.00). Descriptive statistics and chi-square were used to evaluate group differences in weight status. Odds ratios were used to analyze the risk of becoming overweight/obese. Principal component analyses (PCA) using varimax rotation were carried out in order to obtain more information about the structure of social and environmental data and to reduce the number of variables. Spearman correlations were computed to analyze the association patterns between individual, social and environmental parameters and the body mass index for each age group separately. Additionally, binary logistic regression analyses were performed to evaluate the association of sex, migrant status and social as well as environmental factors (population density, unemployment rate, average monthly income, educational level, mean age of population, life expectancy, green areas) and the overweight/obesity rate. $P < 0.05$ was considered as statistically significant.

Results

Sample description

The sample comprised 839 boys (52.1%) and 772 girls (47.9%). 874 children (54.3%) had a background of migration. More than 95% of these children originated from Turkey or former Yugoslavia. Figure 1 presents the percentage of children with a background of migration according to the 23 political districts of Vienna. The highest rates of children with a migrant background were observed in the 5th, 10th, 12th, 15th and 20th district. These districts belong to cluster areas 4 or 7.

Weight status

As presented in Table 2, nearly 20% of the children were overweight or obese by the age of 6 years. At the age of 10, nearly 30 % of the children were classified as overweight or obese. This applied to about 25% of the adolescents at the age of 15. Girls and boys did not differ significantly from each other in weight status at the ages of 6, 10 and 15 years. We found a higher percentage of overweight among children with a migrant background at all age groups. Furthermore, we found a higher prevalence of obesity among children with a history

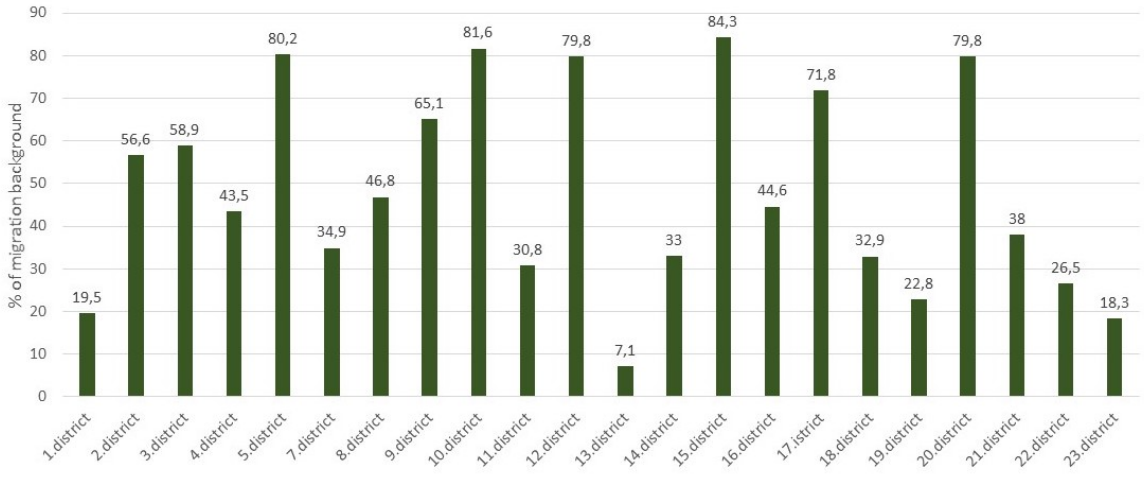

Figure 1 Percentage of children with a migration background according to political districts of Vienna.

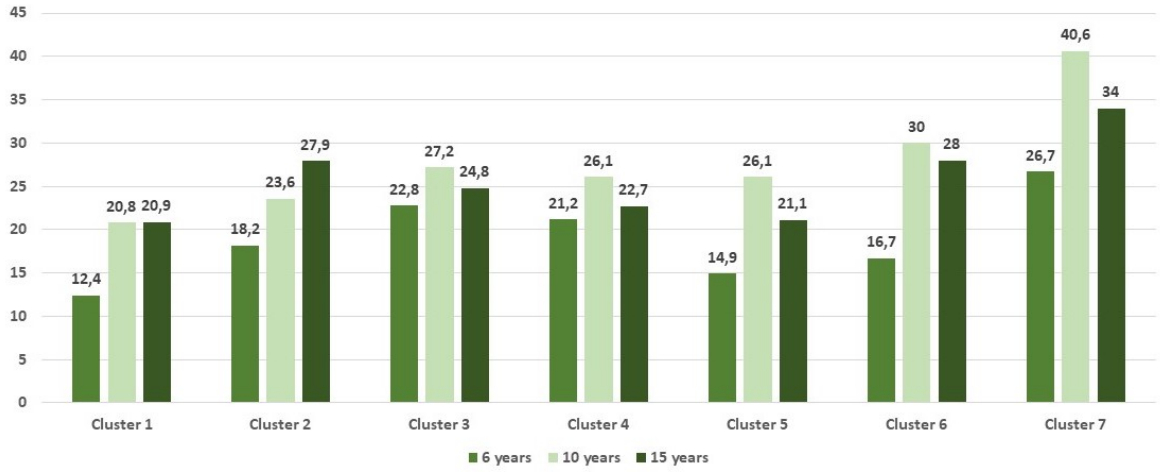

Figure 2 Overweight and obesity rates according to the 7 cluster areas of Vienna.

of migration, at the ages of 6 and 10 years. The risk of being overweight or obese (OR = 1.167 95%CI 1.022 – 1.332) for children with this background was significantly higher (p=0.029) only at the age of 6 years.

Spatial analyses

Rates of overweight/obesity were compared between the 7 cluster areas. Overweight/obesity rates differed significantly between areas (p= 0.001). This applied to all three age groups. The lowest rates of overweight and obesity were found in Cluster 1 and the highest rates in cluster 7.

In a second step the political districts of Vienna were compared. As demonstrated in Figure 3 the prevalence rates of overweight and obesity differed markedly between the individual districts. At the age of six years, girls showed the highest overweight and obesity rates in the 9th, 10th and 15thdistrict, while the lowest rates were found for the 3rd, 4th, 5th and 19th district. Among 6-year-old boys, the highest prevalence rates occurred in the 10th district, the lowest in the 1st, 13th and 19th district. At the age of 10 years, girls showed the highest obesity prevalence in the 15th district, and the lowest in the 13th district. Among their male

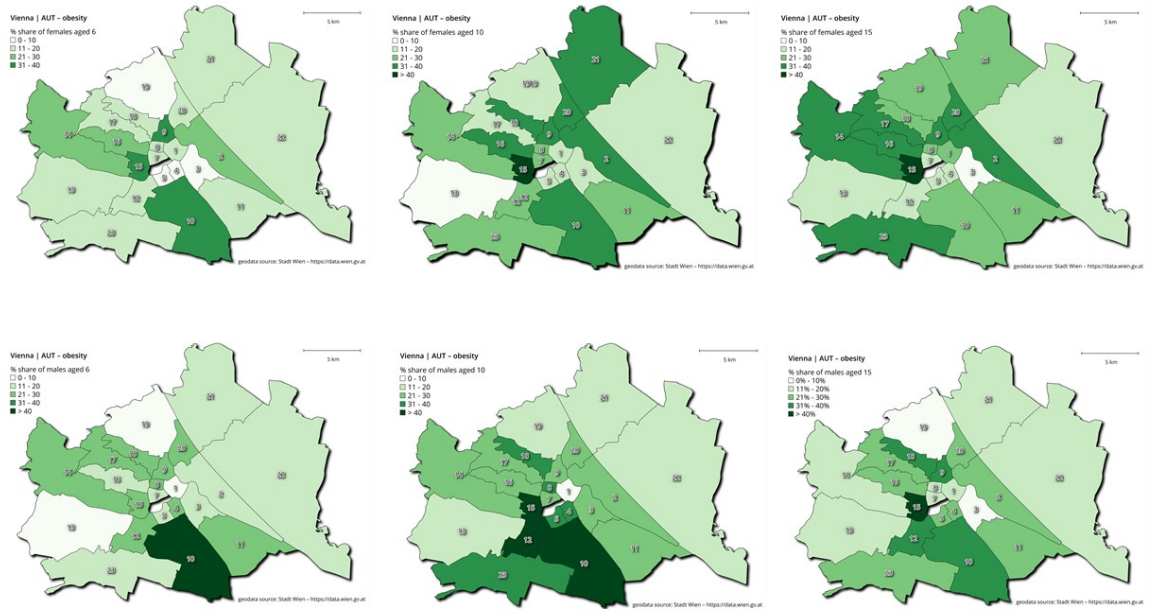

Figure 3 Overweight and obesity rates according to age and sex for each Viennese district.

counterparts, the highest obesity prevalence rates were found for the 10th, 1st and 15th district, the lowest ones for the 1st district. At the age of 15 years, the highest obesity prevalence rates were found for the 15th district, the lowest for the 3rd and the 19th district. This applied to both girls and boys.

As demonstrated in Figure 4 children and adolescents with a migration background, the highest obesity prevalence rates at the age of 6 years were found for the 11th district, the lowest rates were found for the 4th, 5th, 13th and 22nd district. At the age of 10 years, children with a migrant background had the highest prevalence rates of overweight and obesity in the 11th and 15th district, while the lowest rates were found for the 4th district. At the age of 15 years, the highest prevalence rates of obesity occurred at the 15th district the lowest at the 13th, 18th and 22th district. Children without a migrant background of migration in general had lower rates of obesity at the age of 6 years. The highest rates were found for the 10th district. At the age of 10 years, children with no migrant background had the highest obesity prevalence rates in the 10th and 15th district, and the lowest for the 17th district. At the age of fifteen years, adolescents without a migrant background had the highest obesity prevalence rates in the 9th, 10th and the 15th district.

Factors associated with weight status during childhood and adolescence

Spearman rank correlations were computed between the BMI of our participants and the sociodemographic and environmental parameters describing their residence area. The cluster area correlated significantly with the BMI among all age groups, males and females, as well as among children with and without a background of migration. Considering individual social and environmental parameters, BMI was significantly higher with a higher unemployment rate among 10- and 15-year-olds in the total sample. The rate of mandatory education only was consistently positively associated with BMI among 15-

Table 2 Weight status according to sex, background of migration and age group.

		total		male		female		migration history		no migration history	
		n	%	n	%	n	%	n	%	n	%
Weight status at the age of 6a											
	underweight <10th perc	125	7.7%	71	8.4%	53	6.9%	56	6.4%	66	8.9%
	normal-weight 10–90th perc	1166	72.4%	607	72.4%	559	72.4%	622	71.1%	543	73.7%
	overweight 90–97th perc	160	9.9%	78	9.3%	83	10.7%	97	11.1%	65	8.8%*
	obese >97th perc	160	9.9%	83	9.9%	77	10.0%	99	11.3%	63	8.6%'*
Weight status at the age of 10a											
	underweight <10th perc	110	6,8%	62	7.4%	48	6.2%	58	6,6%	52	7.1%
	normal-weight 10–90th perc	1033	64.1%	537	64.0%	496	64.3%	543	62.2%	487	66.1%
	overweight 90–97th perc	279	17.3%	154	18.4%	124	16.0%	160	18.3%	120	16.3%
	obese >97th perc	190	11.8%	86	10.2%	104	13.5%	113	12.9%	78	10.6%
Weight status at the age of 15a											
	underweight <10th perc	66	4.1%	37	4.4%	29	3.8%	35	4.0%	32	4.3%
	normal-weight 10–90th perc	1128	70.0%	599	71.2%	530	68.6%	599	68.5%	528	71.7%
	overweight 90–97th perc	238	14.8%	110	14.2%	119	15.4%	151	17.3%	88	11.9%
	obese >97th perc	179	11.1%	85	10.1%	94	12.2%	89	10.2%	89	12.1%

legend: * p <0.05

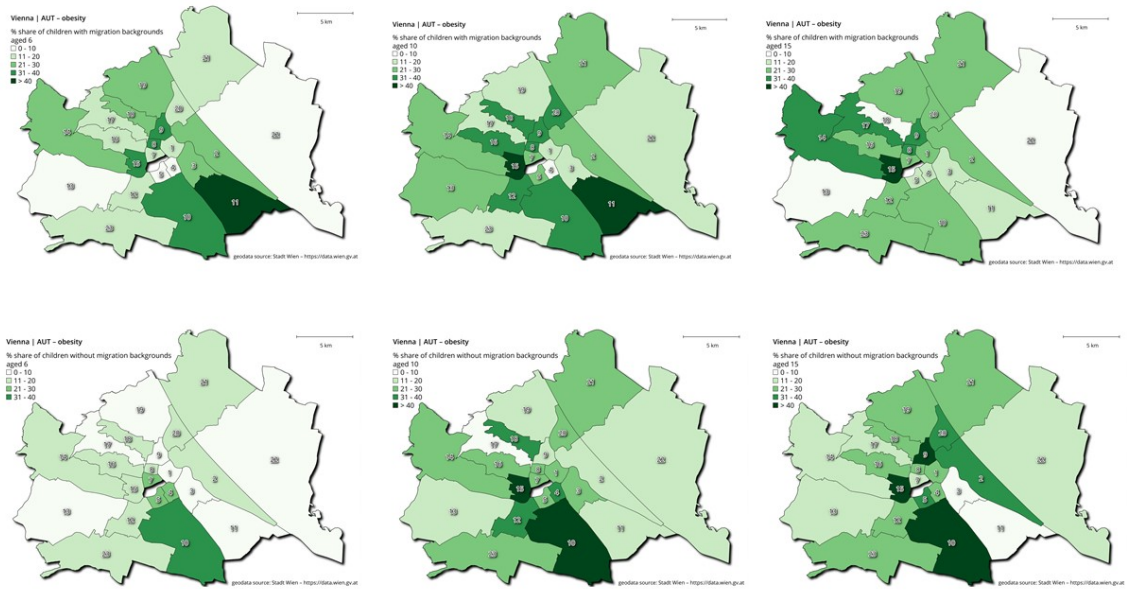

Figure 4 Overweight and obesity rates to migration background for each Viennese district.

year-olds in the total sample, and among males, females, and those with a history of migration. Finally, population density was positively associated with BMI among 6-year-olds and 15-year-olds, but not 10-year-olds Mean monthly income, amount of green areas and life expectancy were significantly negatively correlated with BMI (Table 3).

Principal component analyses

To obtain more information about the structure of exogeneous factors and to reduce the number of variables, PCA of all 10 social and environmental variables (green areas, population density, average monthly income, life expectancy, mean age of population, rate of population with University degree, rate of population with mandatory education only, unemployment rate, migrant rate, cluster area) describing the residential area of the participants was computed. After varimax rotation, PCA yielded two components with an Eigenvalue above 1.0. Component 1 with an Eigenvalue 5.48 represents the "social environment factor" (SEF) with highest loadings for mean monthly income, the rate of people with a University degree, the rate of people with compulsory education only, the unemployment rate, mean life expectancy, mean age in the district, cluster area and the rate of people with a history of migration. Component 2 with an Eigenvalue 2.52 was classified as the "natural environment factor (NEF) with highest loadings district, population density and green areas. Both factors correlated significantly with BMI (Table 3).

The impact of individual, social and environmental factors on overweight/obesity rate

We computed a binary logistic regression to test association patterns between sex, background of migration, the social environment factor as well as the natural environment factor and overweight/obesity for each age group separately. History

Table 3 Body mass index and environmental factors according to sex, the background of migration and age group. Spearman correlations.

	total			male			female			history of migration			no history of migration		
Body mass index	**6a**	**10a**	**15a**	**6a**	**10a**	**15a**	**6a**	**10a**	**15a**	**6a**	**10a**	**15a**	**6a**	**10a**	**15a**
Cluster area	0.12 0.001	0.13 0.001	0.11 0.001	0.14 <0.001	0.11 0.014	0.14 <0.001	0.09 0.017	0.12 0.004	0.08 0.022	0.12 0.002	0.14 <0.001	0.14 <0.001	0.09 0.036	0.04 n.s.	0.05 n.s.
rate of University degree	0.01 n.s.	0.04 n.s.	0.02 n.s.	0.01 n.s.	0.01 n.s.	0.01 n.s.	0.01 n.s.	0.03 n.s.	0.01 n.s.	-0.05 n.s.	0.09 0.010	-0.09 0.005	0.05 n.s.	0.05 n.s.	0.05 n.s
mandatory education only	0.09 0.049	0.12 0.001	0.10 0.004	0.06 n.s.	0.04 n.s.	0.11 0.002	0.03 n.s.	0.11 0.020	0.09 0.002	0.06 n.s.	0.12 0.003	0.12 0.001	0.01 n.s.	0.02 n.s.	0.01 n.s.
unemployment rate	0.05 n.s.	0.11 0.003	0.09 0.046	0.08 0.032	0.06 n.s.	0.10 0.016	0.01 n.s.	0.07 0.044	0.04 n.s.	0.04 n.s.	0.11 0.007	0.09 0.004	0.02 n.s.	-0.01 n.s.	0.01 n.s.
mean age in the district	-0.09 0.049	-0.05 n.s.	-0.05 n.s.	-0.07 0.043	-0.04 n.s.	.0.12 <0.001	-0.05 n.s.	-0.04 n.s.	-0.03 n.s.	-0.08 0.022	-0.11 0.005	-0.08 0.033	-0.02 n.s.	0.05 n.s.	0.03 n.s.
migrant rate	0.16 <0.001	0.16 <0.001	0.14 <0.001	0.13 <0.001	0.10 0.019	0.14 <0.001	0.09 0.012	0.14 <0.001	0.10 0.005	0.09 0.011	0.12 0.002	0.12 <0.001	0.12 0.017	0.05 n.s.	0.12 0.002
Population density	0.12 0.002	0.03 n.s.	0.09 0.013	0.09 0.017	0.03 n.s.	0.07 0.031	0.08 0.028	0.04 n.s.	0.03 n.s.	0.04 n.s.	-0.01 n.s.	0.02 n.s.	0.09 0.011	0.05 n.s.	0.09 0.025
Mean life expectancy	-0.03 n.s.	0.02 n.s.	-0.01 n.s.	-0.01 n.s.	0.06 n.s.	-0.01 n.s.	-0.05 n.s.	-0.03 n.s.	-0.01 n.s.	-0.05 n.s.	-0.07 n.s.	-0.05 n.s.	0.02 n.s.	0.09 0.018	0.04 n.s.
Mean income per months in Euro	-0.12 0.002	-0.10 0.007	-0.12 0.002	-0.11 0.005	-0.05 n.s.	-0.10 0.003	-0.06 n.s.	-0.09 0.018	-0.05 n.s.	-0.09 0.020	-0.13 0.001	-0.14 <0.001	-0.04 n.s.	0.01 n.s.	-0.03 n.s.
Green areas	-0.09 0.002	-0.08 0.008	-0.08 0.002	-0.11 0.004	-0.07 0.049	-0.08 0.026	-0.70 0.049	0.09 0.015	-0.08 0.024	-0.04 n.s.	-0.04 n.s.	-0.08 0.037	-0.12 0.007	-0.09 0.015	-0.08 0.032
Social environment	-0.04 n.,s.	-0.05 0.045	-0.08 0.002	-0.04 n.s.	-0.02 n.s.	-0.07 0.022	-0.04 n.s.	-0.07 0.045	-0.05 n.s.	-0.06 n.s.	-0.12 0.003	0.11 0.003	0.01 n.s.	0.04 n.s.	0.03 n.s.
Natural environment	-0.12 <0.001	-0.04 n.s.	-0.07 0.015	-0.12 0.002	-0.03 n.s.	-0.08 0.009	-0.09 0.023	0.04 n.s.	-0.02 n.s.	0.04 n.s.	0.04 n.s.	0.02 n.s.	-0.13 <0.001	-0.09 0.017	-0.12 0.001

Table 4 Associations between overweight/obesity and sex, the background of migration, the social environment factor and the natural environment factor. Binary logistic regression analyses (normal-weight =1; overweight/obese = 2).

	B	Sig	95% CI	B	Sig	95% CI	B	Sig	95% CI
	6 years			10 years			15 years		
sex	1.09	0.582	0.811 – 1.45	1.04	0.78	0.80 – 1.35	1.19	0.121	0.95 – 1.51
history of migration	1.17	0.049	0.99 – 1.39	1.14	0.048	0.98 – 1.33	1.06	0.440	0.92 – 1.21
Social environment factor	0.95	0.497	0.82 -1.10	0.86	0.033	0.75 – 0.99	0.88	0.029	0.78 – 0.99
Natural environment factor	0.89	0.111	0.76 – 1.03	0.93	0.260	0.82 – 1.06	0.92	0.164	0.82 – 1.04

of migration had a significant positive impact on overweight/obesity at the ages of 6 and 10 years. The social environment factor was significantly associated with overweight/obesity at the age of 10 as well as 15 years. No significant associations with overweight/obesity were found for sex and the natural environment factor (Table 4).

Discussion

The present study is the first one on spatial differences of overweight and obesity during childhood and adolescence in the city of Vienna. Overweight and obesity rates are high in Austria (Statistik Austria, 2021). According to the Austrian Nutrition Report 2017 about 40% of the adult Austrian population correspond to the definition of overweight or obesity (Rust et al., 2017). This is also true of nearly 26% of children ageing between 7 and 10 years (Weghuber et al., 2017). Within Austria, regional differences in the prevalence of childhood overweight/obesity rates have been described. The western and southern region of Austria showed lower rates of overweight/obesity (25.8%), while the highest rates are described for the eastern region (29%). This trend was already described for eighteen years old Austrian conscripts (Rami et al., 2004). Therefore, it might be assumed, that Vienna, which is located in the eastern part of Austria, represents a typical obesogenic environment in comparison to the more rural and alpine central and western parts. This is only partly true, because Vienna is clearly not a homogenous area. As in any big city, individual districts differ markedly in terms of geographic aspects, building density and infrastructure, green areas, economic use and the composition of the population. In addition, districts differ in numerous socioeconomic aspects, which primarily affect rental prices and housing quality and thus also the population of the districts. Therefore, so-called obesogenic environments are not found to the same extent in all regions of the city.

In our study, we were able to show very clearly that certain regions in Vienna have particularly high rates of overweight and obesity among children and young people. Districts 10, 11, 12, 15 and 20, which corresponded to cluster 7 should be mentioned here in particular, while districts such as 1st, 8th, 13th, 18th and 19th , which corre-

sponded to cluster 1 and 2 have markedly lower rates of overweight and obesity
.

The observation of especially high rates of overweight and obesity in the 15th and 12th district correspond to observations reported by Lakes and Burkart (Lakes and Burkart, 2016) for Berlin. We found particularly high overweight and obesity rates in the inner-city areas (e.g., 12th and 15th), but not for the outskirts. Lakes and Burkart, who also reported high rates of childhood overweight and obesity for inner city districts, explained these spatial distribution patterns against socio-economic factors. They found a significant association between overweight and obesity and those in areas with low socioeconomic status and a high proportion of children whose first language was not German (Lakes and Burkart, 2016).

These results are consistent with observations from numerous other studies (De Spiegelaere et al., 1998; Gose et al., 2013; Knai et al., 2012; Kurth and Rosario, 2007; Lioret et al., 2009; Sen, 2013; Stamatakis et al., 2010; Sun et al., 2020). Low socioeconomic status and living in a socially disadvantaged area are major risk factors for obesity among children but also adults (Gnavi et al., 2000; Haas et al., 2003; Lissner et al., 2016; Poulsen et al., 2018). On the one hand, low socioeconomic status influences behavioral aspects in a family such as eating habits and physical activity patterns. It is well documented, that children growing up in low income families tend to consume more fast food, more sugar, fats and soft drinks, and less vegetables, fruits and whole grain products (Mathieson and Koller, 2006); on the other hand, these children are less physically active (Booth et al., 2001). These characteristics may be due to the poor accessibility of supermarkets with better and cheaper food choices as well as a lack of green space in which to play and undertake physical activities.

The association of social parameters and the prevalence of overweight and obesity were also confirmed in the present study. We found a significant positive correlation between the BMI and social environment factors such as the unemployment rate, proportion of the adult population with only a compulsory education, population density and the proportion of people with a migrant background. In contrast, mean monthly income and the size of green areas in the district were significantly negatively associated with BMI. This applies to all age groups, females as well as males, and also children with and without a migrant background. Considering sex and migrant background, only the latter had a significant impact on the risk of being overweight or obese. This is in contrast to the results of the Austrian Child and Adolescent Health Report, which described a higher risk of being overweight or obese for boys (Weghuber et al., 2017).

According to our results, Viennese regions (such as the 10th, 12th , 15th and 20th districts) with low socioeconomic status showed higher rates of overweight and obesity (Boztepe et al., 2019). This connection is not unexpected. Regions with poor infrastructure, little green space, poor housing conditions usually have lower rents than districts with a higher quality of life. People with lower income, low socioeconomic status and often a background of migration settle here. These regions correspond to the definition of an obesogenic environment. These characteristics are typical risk factors for overweight and obesity among urban children and adults (Ogden et al., 2018; Timmermans et al., 2018). Migrant status also increases the risk of overweight or obesity (Brussaard et al., 2001; Faskunger et al., 2009; Kaplan et al., 2004; Kilaf and Kirchengast, 2011; Kirchengast and Schober, 2006; Misra and Ganda, 2007; Singh and Kirchengast, 2011; Wolin et al., 2009). In contrast, neighborhoods

providing a good quality infrastructure, such playgrounds, parks and green areas, regarded as safe and pleasant, seem to support physical activity and reduce the risk of becoming overweight or obese (Ding et al., 2011). Living In these areas is much more expensive. However, in the present study no significant association between parameters of the natural environment, i.e. green areas, population density and the risk of being overweight or obese was observed. The social environment, on the other hand, had an independently significant impact on the risk of being overweight or obese in 10-year-olds and 15-year-olds. At the age of 6, on the other hand, only migrant background had a significantly positive influence on whether one was overweight or obese.

High rates of overweight and obesity in socially disadvantaged areas are to be expected; consequently, lower rates of obesity should occur in more well-off urban districts. This was also true of the present study. Quite low rates of overweight/obesity could be documented for the 1st, 13th, 18th or 19th district. In these upper-class districts not only is the quality of life higher, but also mean life expectancy is more than 7 years longer than in the 15th, 12th, 17th or 20th districts (Bachinger, 2003; Statistik Austria, 2021). Furthermore, the mean monthly income is more than 1200€ higher in the 1st district than in the 15th. Therefore, differences in the prevalence of overweight/obesity between socially disadvantaged and the well-off districts may be explained by the fact that the children belonged to different social strata of Vienna. In our study however, this is only partly true. As pointed out earlier, only children and adolescents attending public secondary schools were included in the sample. Such attendance is a strong indicator of lower family socioeconomic status. Better-off parents tend to send their children to a so-called Gymnasium or to private secondary schools. Do children then with a lower socioeconomic status live in upper-class districts? The explanation for this phenomenon may be a special kind of social politics in Vienna, which started in the 1920s. During the post World War 1 economic depression, the Viennese government of the so-called "Red Vienna" built up so called "Gemeindebauten" which was a special kind of municipal building all over Vienna. Numerous famous architects such as Adolf Loss, Josef Hofmann or Margarete Schütte-Lihotzky were involved in their construction. These public sector houses were erected all over the city in order to enhanced social admixture of the population (Autengruber and Schwarz, 2013). Currently, there are more than 220 000 public sector apartments in about 2300 buildings in all Viennese districts. More than 500 000 people live currently in these buildings. This represents more than 25% of the Viennese population.

We can assume that this may be the reason why children of low socioeconomic status are found all over the city of Vienna, and not only in some socially disadvantaged areas. Our results show that, children of low social status show lower rates of overweight/obesity if they live and attend school in a better-off area. More green areas, more playgrounds, and lower environmental stress seem to have a positive effect on body weight. Nevertheless, even in well-off districts the prevalence rates of overweight/obesity are high in our study. In more socially disadvantaged environments, increased stress may increase the activity of the hypothalamic-pituitary-adrenal axis resulting in increased stress hormone levels typical of obesogenic environments (Congdon, 2019). These areas are maybe less safe, although really unsafe areas are rare in Vienna.

Our study shows that the main risk factor for developing overweight and obesity during childhood and adolescence is the social

environment of the residential area (Bogin, 2021). Children, who grow up in a socially disadvantaged area or an obesogenic environment are at higher risk of developing overweight or obesity. On the other hand, even children with a low socioeconomic status, who grow up in a better-off area also show lower rates of overweight and obesity. Therefore, an improvement of the living situation, such as creating even small green areas, playgrounds in socially disadvantaged densely populated districts in the city center but also special sport programs in public schools and involving the families in workshops focusing on healthy diet and leisure time programs may help to reduce the risk of overweight and obesity for children and adolescents.

Limitations

We are aware that our study has some limitations. On the one hand, this is a retrospective medical record-based study. The data set was provided by the Viennese Medical School Authority. Due to data protection regulations, we had access to limited personal data. We had no information regarding puberty, because no data concerning menarche or voice breaking was provided. Nor do we have information regarding individual social status of the participants and could only be reconstructed via school attendance. Furthermore, the sample size is quite small, only the data of 1611 children could be included in the analysis. Nevertheless, this is the first study focusing on spatial differences in overweight/obesity in Vienna.

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