

“Obesity in the City” – Urbanization and rising obesity rates from the viewpoint of human biology and public health

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Abstract

In 2007, for the first time worldwide, more people lived in urban conurbations than in rural settlement structures. This advancing urbanization has dramatically altered the living situation, the use of space, as well as human behavior along with the health situation and disease burden. This process began in Europe as early as the 19th century, while developing and emerging countries in particular are currently experiencing an increase in urbanization. The burden of disease is clearly altered by living in a confined space, by environmental pollution in urban areas, the impossibility of producing food oneself, and being lost in an anonymous crowd. Obesogenic environments represent a special problem in urban areas. A lack of physical activity, adverse dietary habits, and stressful and unsafe neighborhoods increase the risk of becoming overweight and obese in urban centers. Recently, modernization in rural areas and an adaptation to urban habits there increase the obesity rates in rural areas in high-income as well as low- and middle-income countries, too. Within cities, marked spatial differences in the prevalence of overweight and obesity occur. In Vienna, Austria, overweight and obesity rates during childhood and adolescence differ markedly between the individual Viennese districts. Highest overweight and obesity rates occur in districts characterized by a low socio-economic status.

Take home message for students We are currently confronted with the greatest wave of urbanization in the history of *Homo sapiens*. Urbanization is not only associated with modernization and cities are not only economic and cultural centers and areas of inspiration. Urban centers are also associated with increased psychic and somatic stress, health risks and high rates of obesity.

Introduction

We are currently living in a rapidly changing world. Climate change, transcontinental migration, population ageing, over-population, digitalization, globalization and urbanization represent important stress factors for *Homo sapiens*. They have a major impact not only on economic and social development, but some of those factors also influence biological traits such as growth and development along with health and disease patterns. This makes the above-mentioned parameters of particular interest for both human biology and public health studies.

The association between urbanization and obesity prevalence is steadily gaining importance due to current trends: Twelve years ago, in 2008, a twofold turning point was reached. On the one hand, in 2007, for the first time, more than 50% of the world's population lived in urban habitats; the prediction is that this trend will continue in the coming years and decades (United Nations 2015). On the other hand, in 2008, for the first time in the long history of *Homo sapiens*, the number of overweight and obese people on Earth exceeded the number of people who suffer from starvation and malnutrition (FAO 2008). The association between both trends, e.g. urbanization and rising obesity rates is the topic of this review. In detail, urban environments are discussed from the viewpoint of Evolutionary Anthropology, current urbanization rates and overweight/obesity rates are presented. Particular attention is paid to obesogenic environments and spatial differences of obesity rates among children and adolescents in Vienna, Austria.

Obesity – a worldwide public health concern

Without doubt, obesity represents one of the major worldwide public health challenges of the 21st century (Chooi et al. 2019; Spinelli et al. 2019). Overweight and obesity is commonly defined as an excessive amount of adipose tissue. Among adults a body mass index (BMI) above 25.00 kg/m² is considered overweight, a BMI above 30.00 kg/m² is considered as obese (WHO 2000). Among children and adolescents of the same age and sex, overweight is defined as a BMI at or above the 85th percentile and below the 95th percentile. Obesity is defined as a BMI at or above the 95th percentile for children and teens of the same age and sex (Aggarwal and Jain 2018).

Obesity is mainly seen as a very recent phenomenon because at the population level obesity was rare up to the 1950s (Brown 1991; Haslam 2007). In the second half of the 20th century, however, obesity rates rose sharply in the high-income countries and later also in the emerging countries. Once considered a condition typical solely of affluent societies in the industrialized world, overweight and obesity rates are now fast growing in poor neighborhoods of high-income countries as well as in many middle- and low-income countries (WHO 2000; WHO 2010; Hossain et al. 2007; Pijl 2011; Chooi et al. 2019). Between 1975 and 2016, the world-wide prevalence of obesity nearly tripled (Blüher 2019). According to the World Health Organization (WHO), in 2016, more than 1.9 billion adults (18 years) were overweight (BMI > 25.00 kg/m²); of these, 650 million adults were classified as obese. This means that 39% of the world's adult population were overweight, 13% obese (Chooi et al. 2019; WHO 2020). Figure 1 presents overweight + obesity rates for adult males and females according to

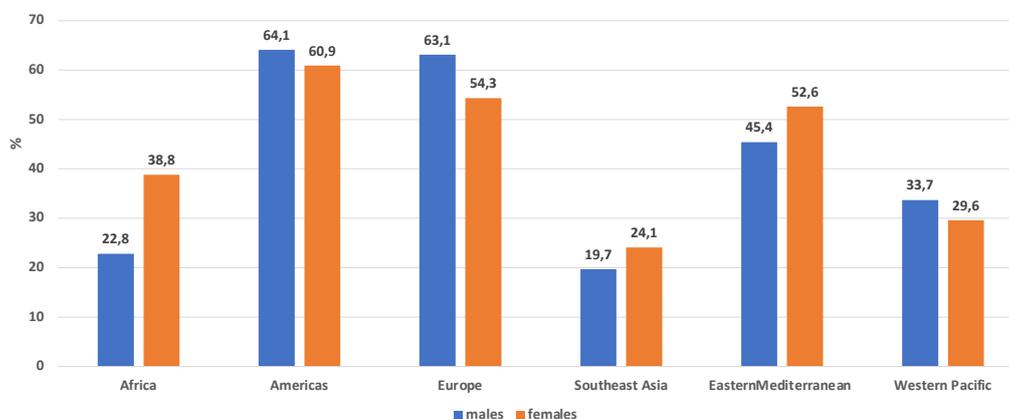


Figure 1 Overweight and obesity rates according to World regions according to the WHO (WHO 2020).

world regions. Lowest overweight and obesity rates are found for Southeast Asia and Africa. The highest rates are found for the Americas and Europe.

A special problem is the rising rates of overweight and obesity among children (Spinelli et al. 2019). In 2016, more than 340 million children and adolescents aged 5–19 years were overweight or obese worldwide. Furthermore, the prevalence of overweight and obesity among children younger than 5 years has increased dramatically. In 2019, about 38.2 million children under the age of 5 years were overweight or obese. This is true not only of high-income countries but also of middle- and low-income countries (WHO 2020). Currently, nearly half of the overweight or obese children younger than 5 years live in Asia. In Africa as well, however, the number of overweight children younger than 5 years has increased by nearly 24% since 2000.

This high prevalence of excessive body weight worldwide is a matter of concern because obesity represents an important risk for premature mortality and morbidity

(Ford and Mokdad 2008; Wang et al. 2011). Furthermore, overweight and obesity are not merely individual health problems – they also place an enormous economic burden on public health and social systems of governments. This makes the analysis of risk factors enhancing the risk of overweight and obesity ever more important. From a physiological point of view, overweight and obesity are caused by an imbalance between energy intake and expenditure (Florentino 2002). On the one hand, this imbalance, is associated with genetic factors. There is no doubt, that obesity is complex heritable trait (Thaker 2017). Beside monogenic causes such as single gene mutations primarily located in the leptin- melanocortin pathway, polygenic obesity is caused by a cumulative contribution of a large number of genes (Thaker 2017). Currently it is assumed that the genetic component may contribute to 40–70% of obesity (Chiurazzi et al. 2020). On the other hand, there is a strong environmental component, which may enhance the risk of obesity. The main environmental reason

for rising obesity rates worldwide is the globalization of increasingly obesogenic environments, which are mainly characterized by rapid urbanization associated with the mechanization of jobs, improved transportation services, the availability of food of high energy density, and reduced physical activity (Popkin and Udry 1998; Popkin 2001; Popkin 2003; Popkin and Gordon-Larsen 2004; Poston and Foreyt 1999; Ulijaszek 2007; Ulijaszek and Lofink 2006).

Urbanization – a problem of definition

Urbanization is apparently related to rising obesity rates worldwide. Before we start to discuss the phenomenon urbanization and its associations with parameters of human biology, such as growth patterns, but also parameters of public health, in particular obesity rates, we have to define the terms urbanization, urban environments, urban centers and cities. Urbanization describes the process by which large numbers of people become permanently concentrated in relatively small areas, forming urban habitats or cities. To date, no uniform definition of the terms city or urban centers exists. A city is commonly defined as a large human settlement, the term "city" however, has different meanings around the world. Some definitions classify human settlements with more than 250,000 inhabitants as cities, while and in some places the settlement can be very small indeed. A town in contrast, is defined as a settlement that is larger than villages, but smaller than cities. An important trait of cities is, that the inhabitants work primarily on non-agricultural tasks (Caves 2005). Even the United Nations (UN) uses regional definitions, which vary considerably from state to state. For instance, the

United States defines an urban place as any locality, where more than 2,500 People live. In contrast, in Peru an urban place is any locality with 100 or more dwellings (Duignan 2019). In Japan, a city is defined as a shi with a minimum of 50,000 inhabitants, while Sweden or Denmark set the threshold at only 200 inhabitants. The most frequently used thresholds for the definition "urban" are 2,000 to 5,000 inhabitants. The European Commission defined urban centers as areas with more than 50 000 inhabitants plus a population density of at least 1500 people per square kilometer (km²). Urban clusters are defined as areas with a minimum of 5,000 inhabitants plus a population density of at least 300 people per square kilometer (km²). Every location with less than 5,000 inhabitants is considered as rural. Therefore, the degree of urbanization differs depending on the definition. According to the definitions of the European commission only 15% of the world population lived in rural areas, while 52% lived in urban centers and 33% in urban clusters in 2016. As presented in Figure 2, major differences in the percentage of urbanization between the UN definition and the European commission definition occur for Africa and Asia. These differences in the definitions of urban areas may contribute to the inconsistent findings of the associations between obesity and urbanization.

Urbanization from the viewpoint of evolutionary anthropology

From the perspective of evolutionary anthropology, urbanization or the trend towards urban forms of settlement is a very recent phenomenon. More than 2 million years have passed since the first appearance of the genus *Homo* (Antón and Snodgrass 2012). Anatomically modern *Homo sapiens* has been recorded for more than

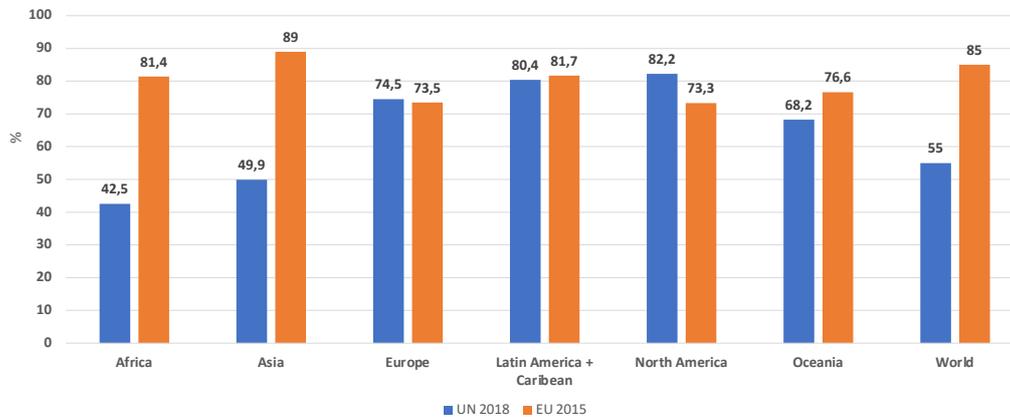


Figure 2 Urbanization world-wide in 2015 und 2018 – a comparison between the definition of United Nations Organization and the definition of the European commission.

150,000 years (Stringer 2016), but the first urban forms of life appeared only around 10,000 years ago (Davis 1955; Wilkinson et al. 2014). The environment in which the evolution to modern humans took place, the so-called "environment of evolutionary adaptedness" (EEA) (Bowlby 1969), therefore differed completely from current urban environments. Our ancestors followed a hunter and gatherer lifestyle characterized by high mobility in small groups without permanent homes. Group size seldom exceeded 100 people (Dunbar 1993), and the daily routine was determined by the search for food and water. Living in crowded cities, overeating and lack of physical activity as a population problem were equally unknown as the holding of domesticated animals with the exception of dogs (Cohen et al. 2013).

As a result of the Neolithic transition, the earliest settlements known as "cities" – such as Jericho, which is located in what is now the West Bank, or Catalhöyük in recent Turkey – emerged around 10,000

years ago (Davis 1955; Mumford 1961; Maher et al. 2012; Wilkinson et al. 2014). The number of inhabitants did not exceed 3,000. According to the current definition, both cities would correspond more to larger villages. A higher number of inhabitants could not have been supported due to food supply problems, because the technical possibilities in the Neolithic would not have enabled feeding a larger population in a limited space. Technical innovations such as irrigation systems, the use of the plow, or metallurgy made it possible to increase production and promoted larger settlements that deserve the name city and comprised up to 15,000 inhabitants. Such cities emerged in Egypt, Mesopotamia, China and India from 3,000 BC (Davis 1955). In the 2nd millennium BC, cities such as Theben were assumed to already have over 100,000 inhabitants. Nonetheless, it was difficult to cross the 200,000 inhabitants limit, as 50 to 90 farmers were still required to produce food for one city dweller (Davis 1955; Cohen et al. 2013). In

the 5th century BC, cities with over 100,000 inhabitants such as Athens, Carthage and Syracuse emerged in the Mediterranean region. Rome was the first metropolis in history. Here, improved agricultural technology, efficient traffic routes and highly developed administration enabled the city dwellers to be fully supplied (Mumford 1961). On the other hand, a high incidence of infectious diseases in urban habitats of the Roman Empire was reported for the 1st century AD by Pliny the Elder in his *Historia Naturalis* and by von Galen in the 2nd century AD (Scheidl 2010). With the exception of Constantinople, ancient Rome represented the only megacity until London became the first metropolis of modern times in the 19th century. Focusing on Europe, urban ways of life established themselves from the High Medieval times, but the population remained comparatively low. In the 14th century, Florence had around 90,000 inhabitants, London around 30,000. The first major urbanization spurt came in the late 18th and especially in the 19th century in the course of the Industrial Revolution (Schott 2014). Starting in England, poverty drove an increasing number of people from rural areas into the emerging industrial cities, thus triggering urbanization. Around 1800 there were fewer than 50 cities with 100,000 or more inhabitants worldwide, with only 1.7% of the world population living in cities with more than 100,000 inhabitants, and 2.4% in cities with more than 20,000. In 1900 these values were 5.5% and 9.2%, in 1950 13.1% and 20.9%, respectively (Davis 1955). In the last few decades this urbanization process has reached the so-called emerging and developing countries and assumed unimagined proportions.

Currently, we are confronted with the greatest wave of urbanization in human history. By 2030, 5 billion people are expected to live in urban conurbations and practice an urban lifestyle. Urbanization is the

result of the growth of existing cities, primarily through rural-urban migration, the so-called physical urbanization. In turn, it also alters the behavior of residents of rural regions in what is termed functional urbanization (Mumford 1961). This increase in the urban population will primarily affect developing and emerging countries, which currently have an urbanization rate of around 48%, whereas in the industrialized countries the proportion of the urban population exceeded the 70% mark in 1990. In particular, this development will present African and Asian countries with high population growth with unexpected challenges in economic, ecological, but also social and health policy terms (Leon 2008; Bork et al. 2009).

The trend is towards megacities with more than 5 or even more than 10 million inhabitants, depending on the definition, as well as polycentric agglomerations such as the Pearl River Delta in southern China (Bork et al. 2009). There are currently more than 50 megacities worldwide, more than two-thirds of which are in developing and emerging countries and are characterized by barely manageable or controllable development. Examples include Istanbul (14 million), Lagos (10 million), Sao Paulo (21 million), Cairo (17 million) Mexico City (20 million), Kolkatta (14 million) or Mumbai (18.4 million), in which the living conditions can often be described as catastrophic. This applies above all to the slum areas, which are primarily inhabited by rural-urban migrants. These urban agglomerations are characterized by overpopulation, environmental pollution, resource consumption, water scarcity, poor hygienic conditions (Qian et al. 2001; Canfield et al. 2003; Schell 2014; Schell 2010; Jaffar et al. 2017), social conflicts and the resulting psychological stress (Calhoun 1962; Dunbar 1993; Ramsden 2009; Logan and Jacka 2014; Miller 2016) – all leading to increased disease risks. At the same time,

however, urban centers are characterized by better educational and work opportunities as well as better access to health facilities (Bork et al. 2009).

Urban environments and parameters of human biology

Body height and growth patterns are widely used as biological welfare measurements and public health indicators. Growth patterns and, ultimately, body height are influenced not only by genetic disposition but also by environmental factors such as resource availability, climate, nutrition, socioeconomic conditions as well as social status and psychosocial factors (Bogin 2021; Schell et al. 2009). Furthermore, growth and body height are associated with individual health status, but also with life circumstances and social and economic conditions on the population level (Komlos 1994; Komlos 1998). Numerous studies have examined the effects of the urban environment on growth patterns during the subadult phase, body height and health (Tanner and Eveleth 1976; Komlos 1986; Rona 2000; Martínez-Carrión and Moreno-Lázaro 2007). Growth inequalities and differences in body height between inhabitants of urban and rural areas are of special interest. Up to the Industrial Revolution, the differences between rural and urban populations in Europe remained insignificant (Kaupová et al. 2013). Thereafter, however, dramatic differences were reported in body height between rural and urban populations, with a clear urban height penalty (Zehetmayer 2013). The body height of rural populations tended to exceed that of urban ones. This urban penalty was mainly due to the low standard of sanitation, high population density, high disease load and higher food prices in towns and emerging Industrial cities (Martínez-Carrión and Moreno-Lázaro 2007). Such adverse urban environmental conditions impaired

growth patterns and ultimately led to a shorter stature among the urban population. Similar trends were observed for the United States: during the 19th and early 20th century, body heights and weights were lower in urban versus rural areas (Carson 2020). By the early 20th century, however, this trend was almost universally reversed. Mortality rates fell and stature height increased due to improved living conditions in European cities, including a reduction of child labor, purification of the water supply, canalization and sanitation, along with advances in the food supply, vaccination programs, medical care and higher incomes (Schonfield et al. 1991; Komlos 1998). The body height of urban populations exceeded those of their rural counterparts. Currently, rural-urban differences in body height have diminished in most high-income countries. In middle- and low-income countries, however, such differences still occur. In Venezuela, urban children were taller and heavier than their rural counterparts. These differences were evident after age 2 and puberty in boys and girls, and persisted into adulthood (Blanco et al. 1992). Major growth inequalities between urban and rural areas have been reported in China over the past 40 years. Economic development and urbanization decreased these differences in body height between children from rural and urban areas, but new public health challenges emerged, in particular rising obesity rates (Zong et al. 2017; Hu et al. 2020).

Urban environments as health risks

Urbanization and urban environments are associated with various health risks. The high population density represents ideal conditions for the spread of infectious diseases. This is because enough hosts live in a confined space, enabling transmission through direct and indirect contact. At the

same time, high population densities also mean a problem for the supply of pure drinking water, sufficient food, and waste disposal. The combination of dense populations and poor hygiene predestines the occurrence of infectious diseases. These patterns of infection incidence were also typical during plague pandemics several centuries ago (Roberts and Lewis 2002), but even today, infectious diseases were more common in urban areas. Beyond well-known infectious diseases such as tuberculosis and influenza, new infectious diseases such as HIV/AIDS, SARs, influenza, and COVID-19 also find an ideal biotope in overpopulated megacities (Bork et al. 2009; Neiderud 2015).

Rapid urbanization has a clear impact on morbidity and mortality patterns (Vlahov et al. 2007; Leon 2008). This is unsurprising because changes in life style and living conditions have always led to changes in the burden of illness. The negative impact of urbanization on health started with the Neolithic transition and the associated first epidemiological transition about 10,000 years ago (Armelagos et al. 2005), when the transition from an appropriative to a productive subsistence forced people to give up a mobile way of life as hunters and gatherers and to become sedentary farmers. The domestication of plants and animals, life in village and later urban communities, and the changed food spectrum drastically altered the burden of disease and reduced life expectancy. Although the main health problems of these early stages of urbanization seem to be the rise of infectious diseases caused by poor hygienic conditions and new emerging zoonoses, nutrition associated health problems gain in importance. For the first time a double burden of malnutrition may be assumed. On the one hand, the more one-sided and, due to crop failures, poor nutrition led to starvation and malnutrition, on the other hand, reduced physical activity and diets

rich in carbohydrates and fat from domesticated animals may increase the risk of overweight for the first time in human history (Cohen et al. 2013).

Malnutrition was still an important health hazard during the second epidemiological transition, which took place during the Industrial Revolution in the late 18th and early 19th centuries. There, the dramatic increase in population combined with rapid urbanization and industrialization led to a dramatic deterioration in the health situation in the emerging industrial cities (Roberts 2016). Beside the adverse effects of environmental pollution from factories, overwork from toiling under inhumane conditions in industrial plants, and catastrophic living and hygiene conditions on health and disease patterns, malnutrition and associated diseases became an eminent problem. People in urban environments were no longer able to produce their food by themselves, they had to buy it and spend a lot of money to get enough food. Between 1780 and 1850 families in British industrialized cities had to spend about 75% of their income on food (Griffin 2018). Consequently, malnutrition and starvation were quite common. On the other hand, since the industrial revolution refined grains and sugar have been consumed in huge quantities, resulting in a frequent intake of high-glycemic index carbohydrates, which are digested and absorbed quickly (Matthews 2012). The double burden of malnutrition was omnipresent in the urban environment during the Industrial Revolution.

The third epidemiological transition is currently taking place. The considerably improved living conditions in the industrialized countries, combined with the enormous advances in disease control and prevention, have led to completely new disease patterns in the last few decades. Improvements in medicine, hygiene and vaccination programs pushed back infectious

diseases. This increased life expectancy, but the accompanying hyperalimentation and rising obesity rates promoted so-called diseases of civilization or non-communicable diseases such as cardiovascular diseases, metabolic disorders and cancer (Pollard 2008).

Urban environment and obesity

Obesity rates are increasing worldwide, currently more rapidly in rural than in urban areas (NCD Risk Factor Collaboration 2019; Mahase 2019). This increase in rural areas seems confusing at a first glance because obesogenic environments are mainly found in urban areas. One possible explanation may be, that rising obesity rates in poor rural areas reflect nutrition and developmental assistance programs in low- and middle-income countries, but also the expansion of an obesogenic environment from urban areas to rural ones (Mou et al. 2013; Paciorek et al. 2013; Khan and Kraemer 2014). Interestingly, the steadily increasing urbanization rates unfortunately did not help reduce obesity rates in urban settlements. Even there, rising rates of overweight and obesity represent a public health challenge. Another possible explanation for this interesting trend of rising obesity rates in rural areas may be the different definitions of rural and urban areas, which are used in different countries. As pointed out above, there is no generally accepted definition what is a village, a city, a town or what is rural, what is urban.

Figure 3 presents a comparison of urbanization rate and overweight + obesity rate according to the World Bank income regions. This comparison shows, that the urbanization rate as well as the overweight obesity rate among adults drops down with decreasing income. The lower the urbanization rate, the lower is the overweight+ obesity rate.

In order to discuss the effects of urban environment on overweight and obesity rates, it is necessary to define an obesogenic environment. According to Swinburn et al. 1999, an "obesogenic environment" is "an environment that promotes gaining weight and one that is not conducive to weight loss" within the home or workplace. Thus, the obesogenic environment refers to one that helps, or contributes to, obesity. But what are the characteristics of such an environment? The main characteristics are conditions that reduce physical activity, a food environment that promotes the availability and accessibility of cheap food rich in fat and sugar, and social neighborhoods that are unsafe and stressful. Other typical obesogenic environments are low-density areas with segregated land use, low connectivity and a high dependence of car use, but also conditions which discourage walking, bicycling to schools or workplaces, or outdoor physical activity during leisure. Note, however, that such conditions can equally be found in nice middle-class suburban areas and in unsafe socioeconomically disadvantaged neighborhoods (Congdon 2019). Finally, a high density of fast food outlets, convenience stores offering processed energy-dense food, as well as a stressful social environment and unsafe neighborhood that address the hypothalamic-pituitary-adrenal axis and thus increase stress hormone levels are typical of obesogenic environments (Congdon 2019).

For a long time, this type of environment was interpreted as being typical of socioeconomically disadvantaged urban areas in high-income countries. Today, such environmental conditions are increasingly found low- and middle-income countries, in particular in rural areas which adopt these characteristics to interface with modernization and globalization processes.

Overweight, obesity and associated metabolic diseases are typical of the current third epidemiologic transition (Armela-

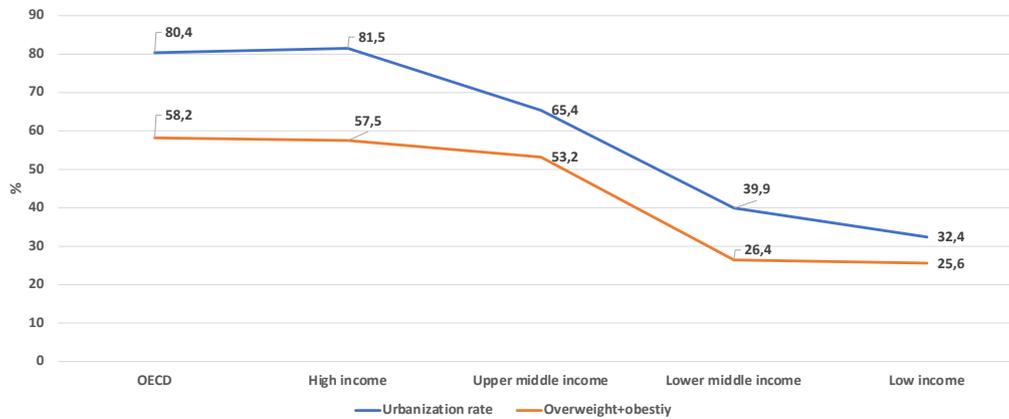


Figure 3 Overweight and obesity rates according to income regions according to the World Bank (Shekar and Popkin 2020).

gos et al. 2005; Barrett et al. 1998). Obesogenic environments are clearly the result of modernization processes, which started more than 50 years ago in high-income countries and now sprawl throughout the world. Technical advances and modernization of lifestyle result in a marked transition in human life. The daily energy effort to gather and prepare sufficient food is reduced to nearly zero because only few individuals work in food production. Mechanized transportation, sedentary jobs and labor-saving household technologies reduce physical activity too. At the same time, more than enough energy-dense food, mainly consisting of sugar and fat, is easily available (Popkin 2001; Popkin and Gordon-Larsen 2004; Lieberman 2006; Eaton and Konner 1985). Once a problem of the industrialized world, globalization, modernization and urbanization now promote obesogenic environments and enhance the risk of overweight and obesity in rural as well as urban areas of developing countries. These include Indonesia (Nurwanti et al. 2019), India (Ebrahim et al. 2011),

China (Dong et al. 2019; Shen et al. 2019), Guatemala (Groeneveld et al. 2007), or Peru (Antiporta et al. 2016; Najera et al. 2019). In developed countries, poor neighborhoods, low socioeconomic status and a background of migration are typical risk factors for overweight and obesity among urban children and adults (Timmermans et al. 2018; Ogden et al. 2018).

Today, in high-income countries such obesogenic environments are mainly found among lower socioeconomic groups, characterized by low incomes, low educational levels and living in a poor and unsafe neighborhood (Ball and Crawford 2005; Hook and Balistreri 2007; Faskunger et al. 2009; Wang and Beydoun 2007). These conditions are frequent in urban environments. In middle- and low-income countries, in contrast, this relationship is reversed. People of high socioeconomic status who underwent a rapid transition in nutritional habits and general life style are more likely to be obese. In societies of economic and nutritional transition, the paradox situation is that malnutrition and obesity rise

in parallel (Chatterjee 2002). Moreover, numerous investigators have demonstrated that migrant status increases the risk of overweight or obesity. This is true of rural-urban migrants in low-income countries, of Hispanic immigrants in the United States (Kaplan et al. 2004), as well as of immigrants originating from Mediterranean countries or the Middle East in Central and Northern Europe (Brussaard et al. 2001; Kirchengast and Schober 2006; Misra and Ganda 2007; Wolin et al. 2009). Immigrant obesity is the result of rapid modernization and a fast transition into an obesogenic environment.

An especially dramatic stress factor is transnational rural-urban migration. On the one hand, urban conurbations are particularly attractive for migrants due to their mostly multicultural character but also due to the diverse work and educational opportunities. On the other hand, such transnational migration increases the risk of illness because migration and integration into a new cultural environment are stress factors per se. In addition, immigrants often have a lower social and socioeconomic status than the guest population and therefore live in cheaper and typically more polluted and disadvantaged residential areas (Gushulak and MacPherson 2006). Finally, a lower level of education and poor language skills impede access to medical facilities (Carballo et al. 1998). Migration from rural regions to an urban environment in another country therefore often represents a double stress situation. Less daily physical activity and the availability of cheap, sugar- and fat-rich food increase the risk of becoming obese. Thus, a significantly increased risk of obesity and associated diseases was documented for Turkish and Indian women who had migrated from rural regions in their home country to the city of Vienna (Kilaf and Kirchengast 2011; Kirchengast et al. 2012). The obesity prevalence among migrant

women was significantly higher than that of women in their region of origin as well as of Viennese women without a migration background. The main reasons for this are probably changes in eating habits and a lack of exercise.

Overweight and obesity in Austria

Overweight and obesity rates are high in Austria. As presented in Figure 4, during the last 15 years about 40% of adult males and more than 25% of adult females were classified as overweight (BMI between 25.00 and 29.99 kg/m²). Since 2006, the rates of obesity (BMI >30 kg/m²) increased among males from 12.4% in 2014 to 17.9% in 2019. Among adult females, obesity rates increased from 13% to 15% during the same period (Bundesanstalt Statistik Österreich 2019).

Furthermore, regional differences in the obesity prevalence are observable (Figure 5). The analysis of conscript data revealed lowest rates of overweight and obesity in the rural Western areas of Austria and the highest overweight and obesity rates for the more urbanized Eastern parts of Austria (Rami et al. 2004).

Childhood overweight and obesity in Vienna, Austria

A special problem represents the increasing rates of obesity and overweight among children and adolescents (Ebbeling et al. 2002; Kimm and Obarzanek 2002; Wang and Lobstein 2006; Lasserre et al. 2007; Han et al. 2010). On the one hand obesity during childhood and adolescence has long-term health consequences (Must et al.

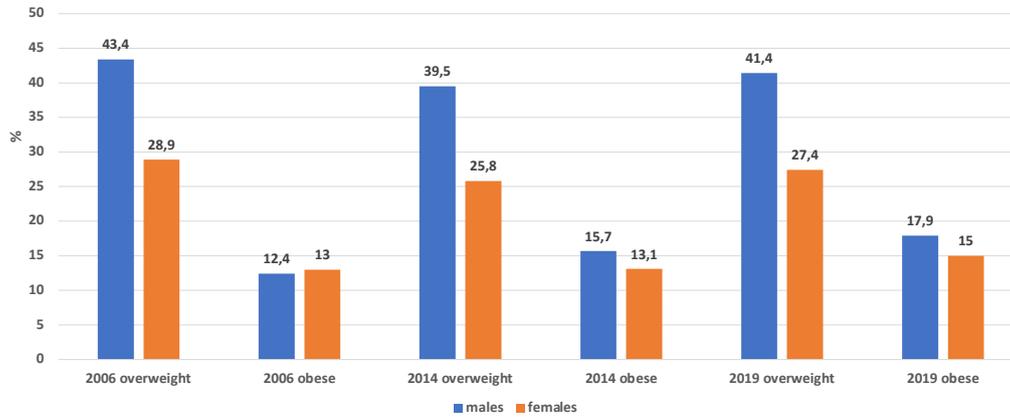


Figure 4 Overweight (BMI 25.00 to 29.99 kg/m²) and obesity (BMI > 30.00 kg/m²) among Austrian adults between 2006 and 2019 (Bundesanstalt Statistik Österreich 2019).

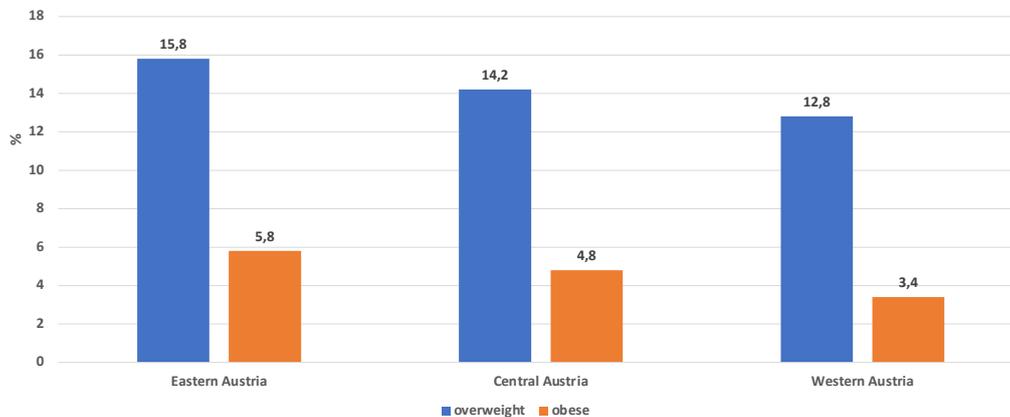


Figure 5 Overweight (BMI 25.00 to 29.99 kg/m²) and obesity (BMI > 30.00 kg/m²) among Austrian conscripts according to Austrian region (Rami et al. 2004).

1992; McGee 2005), on the other hand childhood obesity predicts individual and global economic problems (Withrow and Alter 2011). One risk factor for obesity among children but also adults is a low so-

cioeconomic status (Gnavi et al. 2000; Haas et al. 2003; Lissner et al. 2016; Poulsen et al. 2018). Therefore, spatial disparities in the prevalence of overweight and obesity in

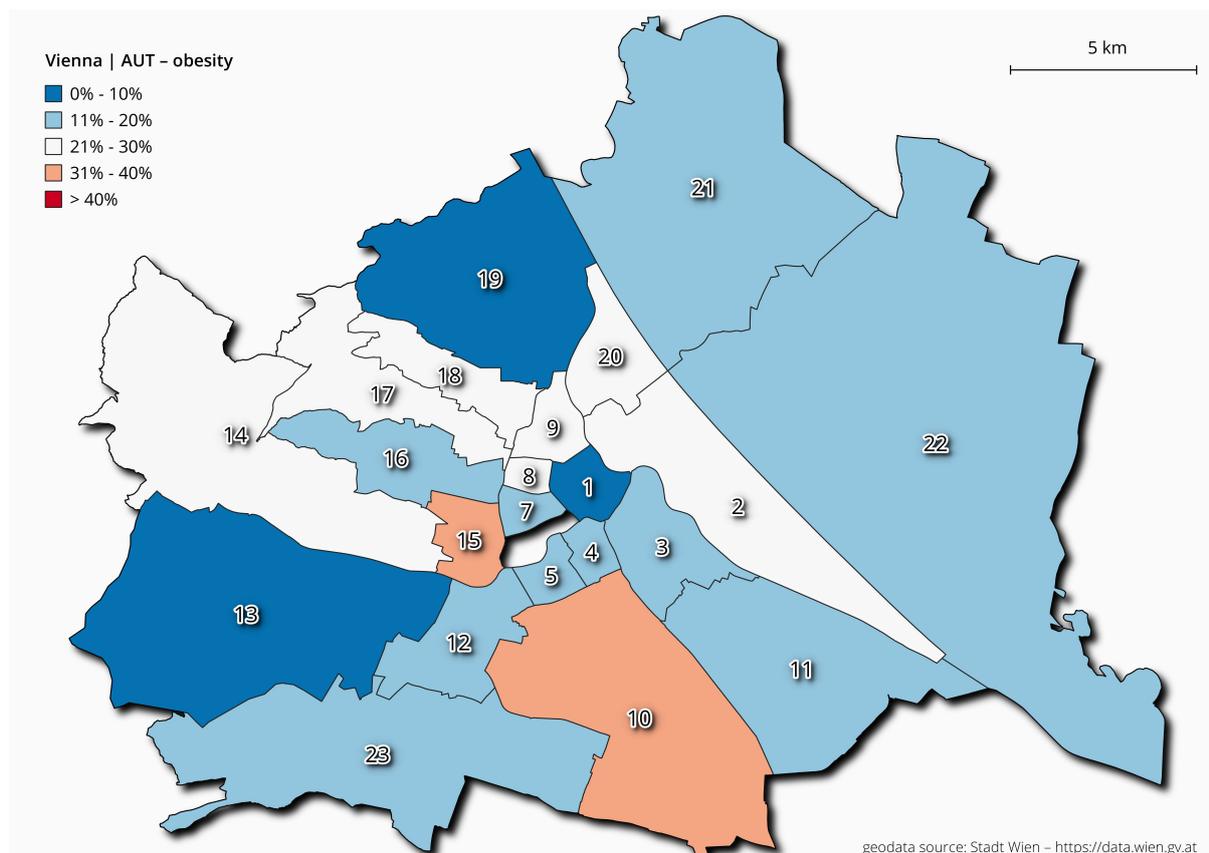


Figure 6 Overweight and obesity rates among 6-year-old children for each Viennese district.

urban centers can be found (Kirchengast and Hagmann 2021).

As noted above, advancing urbanization is also associated with characteristic disease risks, obesity being one example. Importantly, however, caution is advised against generalizations, considering the current urbanizing world. Urban centers or cities are not homogeneous environments. This also applies to the national and international comparison of cities; even within a city, the individual districts differ in their economic, social and ecological characteristics, and these are reflected in a regional variation of disease risks even within a city. In Vienna, for example, life expectancy varies considerably between the individual districts. In Vienna's upper-class districts such as the 13th or 19th districts, life expectancy is more than 7 years longer than in more disadvantaged areas such as the 15th, 12th, 17th or 20th districts (Bachinger 2003; Bun-

desanstalt Statistik Österreich 2019), although the spatial distance between the districts is quite small. These differences in life expectancy depend mainly on the economic and social characteristics of the respective district.

Equally, obesogenic environments differ between the individual districts. This is reflected in the high prevalence of obesity among children and adolescents in socially disadvantaged districts of Vienna (Kirchengast and Hagmann 2021). In our study we analyzed a medical record-based dataset which was provided by the Viennese school medical 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 the Viennese school authority. In Austria, it is obligatory that – beside medical data – the body height and body weight of all school children are collected

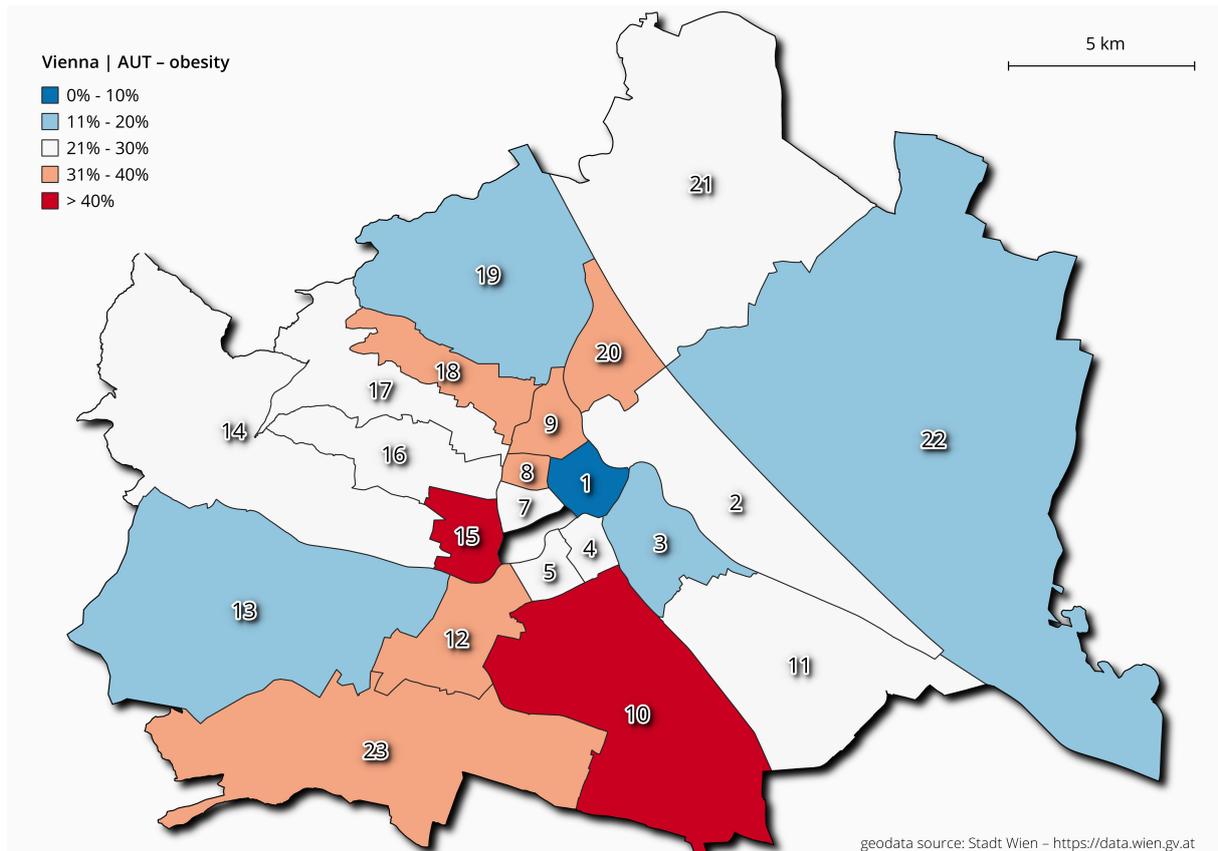


Figure 7 Overweight and obesity rates among 10-year-old children for each Viennese district.

by specially educated personnel of the medical school authority. The data file including all information on body heights and body weights are stored by the Viennese school medical office, to which we had access. We analysed the data of 2,006 boys and 1,840 girls. Weight status was classified according to the percentiles published by [Kromeyer-Hausschild et al.\(2001\)](#). These German charts are used because no validated Austrian charts exist. A BMI(kg/m^2) above the sex and age specific 90th percentile was defined as overweight, a BMI 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. In order to compare the overweight and obesity rates between the 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 in 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 2011](#); [Stadt Wien 2012](#)) 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’ after Jenks ([Jenks and Caspall 1971](#); [Smith et al. 2020](#)) to cluster the percent share of children per district and then manually defined breaks to classify the anthropological dataset.

As demonstrated in Figures 6, 7 and 8, the prevalence rates of overweight and obesity differed markedly between the individual districts. The rates within Vienna show

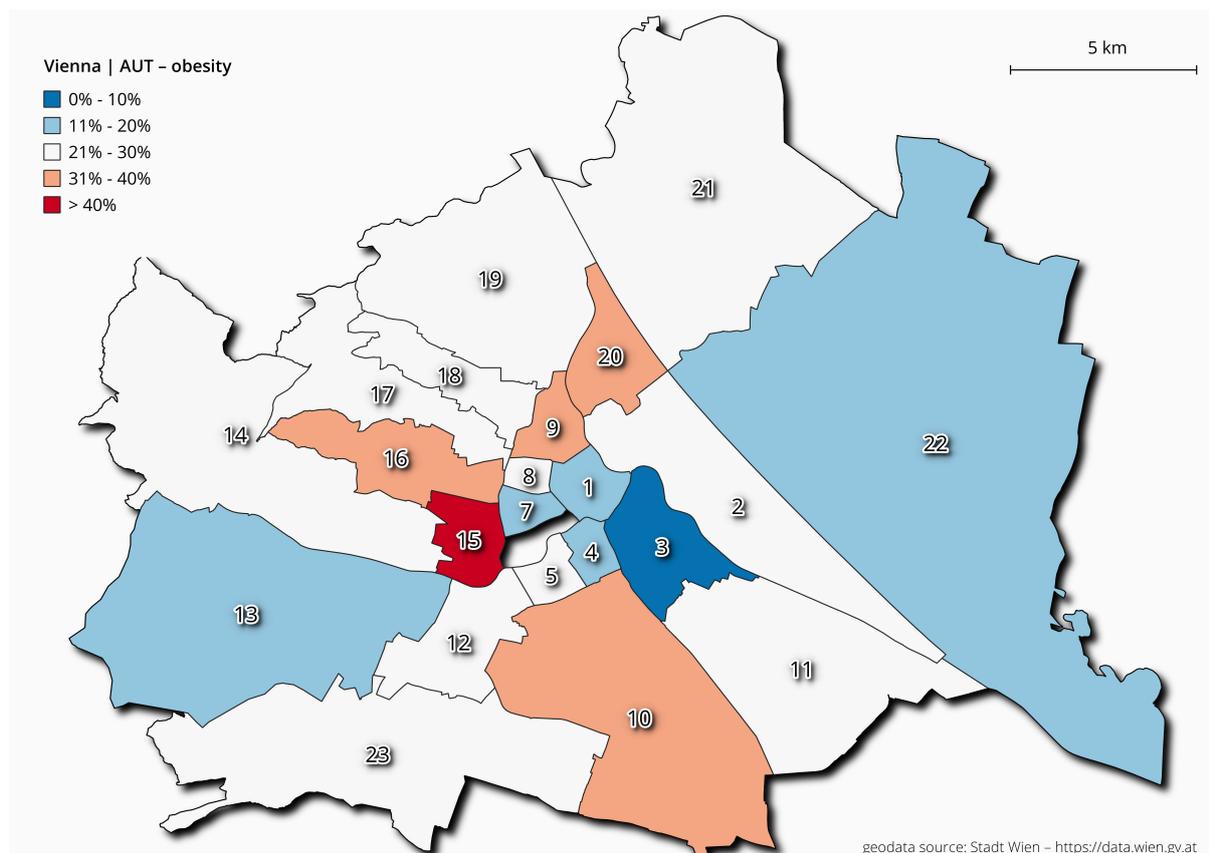


Figure 8 Overweight and obesity rates among 15-year-old adolescents for each Viennese district.

spatial patterns that seem to correlate with the socioeconomic characteristics of the districts. Among six-year-old children, the lowest rates of overweight and obesity (<10%) were found in the 1st, 13th and 19th districts (figure 6). These three districts are the most expensive areas of Vienna and are characterized by a high quality of life, typical of inhabitants with a higher socioeconomic status. In contrast, the highest prevalence (>30%) occurred in the 10th and 15th districts, both characterized by a lower socioeconomic status, poorer living conditions and a high rate of inhabitants with a background of migration (Boztepe et al. 2019). At the age of 10 years, the situation became worse for the children (figure 7). With the exception of the 1st district, the prevalence rates of overweight and obesity are above 10% in all Viennese districts. In the 15th and 10th districts the prevalence rates increased to more than 40%. In six

districts the rates were between 30 to 40%. Among the age group 15 years, the 15th district still showed the highest values (Figure 8). The analyses clearly show marked spatial distribution patterns of overweight and obesity among Viennese school children. There is no doubt, that urban environments are not homogeneous areas, but we clearly see that distinct differences between individual districts exists. Obesogenic environments are mainly found in distinct districts, characterized by a high proportion of inhabitants with lower educational level, lower socioeconomic status and a higher amount of inhabitants with a background of migration such as the 10th and 15th district in Vienna.

Conclusion

Urban centers are not only a place of innovation and economic and cultural diversity; they are also living spaces that harbor a multitude of health risks. From the viewpoint of evolutionary human biology, *Homo sapiens* is apparently still insufficiently adapted to modern urban life. The 10,000 years of life experience in village communities, the few thousand years in urban habitats, and the few decades of experience in megacities were simply too short to enable adequate adaptation to these environmental conditions. A special problem represents living in an obesogenic environment, typical of today's urban centers and urbanized rural areas. Urbanization or urban lifestyle and increasing rates of overweight and obesity are interwoven. Therefore, both urbanization and obesity are major topics of public health and human biology research.

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